Climate Policy and Political Viability: Polarization, Inequality, and the Prospects for Geoengineering

Christopher J. Miller

Submitted to the faculty of the University Graduate School
in partial fulfillment of the requirements for the degree
Doctor of Philosophy
in the School of Public and Environmental Affairs,
Indiana University
August 2020

Accepted by the Graduate Faculty, Indiana University, in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

Doctoral Committee

____
Chair: Daniel Cole, J.S.D.

____
Lisa Blomgren Amsler, J.D.

____
Marjorie Hershey, Ph.D.

____
Sean Nicholson-Crotty, Ph.D.

July 28, 2020

For E.R.

Acknowledgements

This work comes at the end of a long journey involving many people, and no set of acknowledgments can hope to be complete. Nonetheless, I can but try.

Thanks are due first and foremost to my dissertation committee, especially my advisor, Dan Cole. Dan stepped ably into the role partway through my program, and was a steadfast and patient source of intellectual and moral support and encouragement, as well as endless diverting political digressions. He shared my conviction that what makes this kind of work meaningful is not the methods we use, but the questions we ask. Thanks likewise to Margie Hershey, Lisa Blomgren Amsler, and Sean Nicholson-Crotty, who stepped up when I needed them and helped see me through to the finish.

From the beginning of my graduate studies, none of this would have been possible without Evan Ringquist, without whom I literally would not have been at Indiana University, for multiple reasons. Evan was a superlative scholar, teacher, mentor, and human being, and when he passed away in 2014 it was an inestimable loss to the IU community and the intellectual world.

Thanks also to the many other IU faculty who provided wisdom, encouragement, and support along the way. Burney Fischer and Mike McGinnis helped me shape an inchoate mass of ideas into a meaningful research proposal. Lin Ostrom (and all the other scholars, students, and staff of the Ostrom Workshop in Political Theory and Policy Analysis) showed me a remarkable environment in which ideas could be cultivated and problems grappled with through open discourse and interdisciplinary collaboration. Sanya Carley helped guide and shape my research techniques and sensibilities as a very raw grad student, and parts of Chapter Two of this dissertation were originally co-authored with her and published, in earlier form, in *Policy Studies Journal*. Ken Richards, and the concepts and insights I encountered in the IU at Oxford program he led, sparked insights and interests without which this dissertation would not exist. Barry Rubin took me under his wing when I was just learning to teach, and provided friendly guidance and thought-provoking projects through multiple summers. Bill Scheuerman was unfailingly helpful in finding me teaching opportunities to see me through to the end of my program.

Looking back beyond my years at IU, I owe special thanks to J. Mark Hansen, whose political science classes excited me as an undergrad at the University of Chicago, and who was the first professor to suggest I consider an academic career. I disregarded his advice then in favor of law school, only to return years later asking him for a letter of recommendation for doctoral studies, and he was more than happy to oblige. Also instrumental were B.J. Shoemaker and Michael Kaplan, who tirelessly encouraged me to return to the halls of academia during my years away from them.

I owe a tremendous debt of gratitude to my family, of course, especially my parents, Doug Miller and Diane Swensen Miller, and my aunt and uncle, Doreen Swensen and Phil Hall. From my earliest years they taught me to enjoy the life of the mind, and instilled the conviction that I could achieve any goal I set my mind to. My mother, in particular, exemplified those values when she demonstrated that a mid-life career change was neither impossible nor impractical by becoming the first doctor in the family. Now, finally, they can all stop asking me when I will graduate. :)

These last few years would have been much more grueling without the kindness and camaraderie of the friends I made in SPEA and the department of Political Science, and throughout IU and the entire Bloomington community. Of particular note are Adam Abelkop, DaeWoo Lee, Christina Motilall, and NaLette Brodnax, among many comrades, colleagues, and drinking companions who occupy the unique terrain of understanding this experience because they were in the same boat at the same time. Special thanks are due to my dear friend Abby Houppert, who generously read and critiqued my dissertation proposal at a critical stage in its development and provided thoughtful, helpful feedback. I am also grateful to the entire Bloomington social dancing community and the indispensable social support network it provided, especially Caitlin Baird Teague, who urged me to try swing dancing as a relief for the stress of first-year statistics and thereby introduced me to a life-changing pastime, and Jeff Slone, who helped me branch out and develop those skills in whole new directions.

It would be remiss of me not to mention the stalwart support staff in SPEA and Political Science, who know where all the bodies are buried and have helped me and so many other grad students (and faculty) navigate the maze of university bureaucracy—and special thanks especially to Donna Pritchett, first among equals in this company, whose generous help and sincere concern made a world of difference on countless occasions.

Finally, of course, my continuing gratitude goes out to my girlfriend, Yucong Jiang, whose love, support, and understanding have meant the world to me, and kept my spirits up during the endlessly stressful home stretch. We made it!

There are countless other people who deserve a mention as well, people who, even when I doubted myself, never doubted me. Thanks go out to all of you. It really made a difference. Indiana University was a wonderful place to be a graduate student, and Bloomington was a wonderful place to live, and I was honored to be part of that community and to work, live, and socialize alongside so many outstanding people. Thank you, everyone.

All errors and omissions are, of course, mine alone.

Christopher J. Miller

CLIMATE POLICY AND POLITICAL VIABILITY:
POLARIZATION, INEQUALITY, AND THE PROSPECTS FOR GEOENGINEERING

Climate change is a politically fraught policy domain. It is beset by complications including a long-term time frame, increasing severity, time-inconsistent preferences resulting in irrational economic discounting, low incentives for responsible parties to act, and more. Moreover, in the United States political polarization means resistance to climate policy action has been high for many years, for reasons unrelated to the substantive merits of actual or potential policy proposals.

Most scholarship on climate policy focuses on traditional metrics, notably economic efficiency and/or scientific effectiveness. Political viability—the prospect of actually being enacted—is too often mentioned only in passing. No matter how well-designed, though, a policy that falls short of real-world political viability can be neither effective nor efficient. The purpose of this research is to cast a more politically attuned eye on climate policy options—to map a course forward using political viability as a compass.

A few climate policy options—specifically, those often categorized as "geoengineering"—elicit less political resistance from the general public. However, public opinion alone is neither necessary nor sufficient for policy formation, as increasing economic inequality has driven representational inequality as well.

This dissertation analyzes the effects of both polarization and economic status as filters for the political viability of climate policy options in general, and geoengineering in particular.

Part One investigates the process of state-level adoption of innovative climate policies. The approach is sequentially quantitative, then qualitative. It first updates a published event history

analysis of the factors influencing past policy adoptions, then examines the experiences of state-level policy actors using semi-structured interviews.

Part Two investigates the attitudes of individual economic elites, gathering data through a survey experiment and analyzing it to determine elites' degree of openness to climate policy interventions in a geoengineering context.

Part Three investigates the behavior of economically elite organized interests, assessing their revealed preferences on geoengineering initiatives. The approach is mixed-method, employing qualitative comparative analysis to interpret relevant case studies and underlying conditions.

As a whole, this dissertation charts a course that skirts conventional political obstacles, identifying the characteristics of climate policies that might get off the drawing board.

Chair: Daniel Cole, J.S.D.

Lisa Blomgren Amsler, J.D.

Marjorie Hershey, Ph.D.

Sean Nicholson-Crotty, Ph.D.

Table of Contents

List of Tables and Figures

1 INTRODUCTION

As a domain for policy intervention, climate change is a political minefield, with the debris of past attempts to address it lying scattered across the landscape. Many of the challenges to navigating that minefield are inherent in the nature of the problem: it is situated within the larger domain of environmental policy, home to many "wicked problems" (Rittel and Webber 1973). Wicked problems (e.g., "poverty" is an archetypal example) are problems so complex as to defy consensus both on how they are to be conceptualized and on how they are to be solved. Indeed those dilemmas are intertwined: such problems are characterized by ambiguities involved in defining them; causal interdependencies with other problems; diverse and conflicting cognitive frames; multiple stakeholders with conflicting interests; no definitive set of potential solutions; and no clear criteria for assessing whether an attempted solution is effective or complete.

Climate change in particular is a dilemma that rises further to the level of a "super wicked" problem (Lazarus 2009), beset by additional complications including a long-term time frame; increasing severity over time; time-inconsistent preferences resulting in irrational economic discounting of future costs and benefits (Levin et al. 2012); Knightian uncertainties (i.e., risks that cannot reasonably be estimated) (Cole 2008); low incentives for responsible parties to act; and the absence of a clear governing authority (Keohane and Victor 2011).

Such an array of challenges is not necessarily insurmountable, but even under the best of conditions it would pose serious obstacles to both legislating and implementing policy responses to the complex threat posed by climate change. In the United States today, the policy process is not operating under the best of conditions. Divided government, strong ideological polarization along party lines, and increased economic inequality all exacerbate the difficulties already inherent in climate policy formation (Sunstein 2007). There is no shortage of promising policy instruments or designs, but political resistance to climate policy action has been high for some years now and remains so today, as stakeholders engage in motivated reasoning for reasons unrelated to the substantive merits of actual or potential policy proposals.

Political resistance can be a significant cost factor in assessing policy costs and benefits (Richards 2000; Krutilla 2011), yet it is too often neglected by analysts. Most scholarship on climate policy focuses strongly on traditional metrics of policy analysis—notably the economic efficiency and/or scientific effectiveness of any given policy instrument or combination of instruments. Political viability—the prospect of a policy proposal actually being enacted and implemented, given the interests motivating those who influence and direct the policymaking agenda—is all too often mentioned in passing (Fullerton 2001) or not at all.

Taking explicit account of political viability could allow advocates and policymakers to design, shift attention to, and ultimately enact policies that—even if not strictly optimal according to rigorous scholarly criteria—could achieve greater strides toward mitigating and adapting to climate change than alternatives that remain perpetually on the drawing board. No matter how well-designed, a policy that falls short of real-world political viability can be neither effective nor efficient. The purpose of this research is to cast a more politically attuned eye on climate policy options—to map a course through the minefield using political viability as a compass.

1.1 Background, Justification, and Research Focus

In order to better understand the parameters of this challenge and lay the groundwork for subsequent chapters of this dissertation, this section will focus on an overview of the traditional range of climate policy instruments, as well as possible alternatives; political polarization, and its effects on public opinion concerning those policy options; and the additional challenges posed by economic and representational inequality.

1.1.1 The Climate Policy Toolbox

Given the complexity of the policy domain, it is unsurprising that scholars and policy entrepreneurs have devised a wide array of promising ideas for climate policy instruments, as well as designs incorporating multiple instruments. As the literature demonstrates, these can be organized and compared in many ways.

One conventional demarcation of policy designs is between traditional prescriptive regulations (*aka* "command and control"/ "C&C"), and the more recent trend (from the 1980s forward) of "market-based" instruments (MBIs) emphasizing economic incentives. In this context especially, climate policies are often analyzed in combination with environmental policies that are not directly climate-related. Fullerton (2001), for instance, builds a framework to categorize eight types of environmental policy instruments, divided into three categories—including the two dimensions just described, C&C regulations (e.g., emission restrictions, design standards) and market incentives (e.g., emission taxes, subsidies, permits), as well as Coasean bargaining regimes—with an emphasis on economic efficiency and distributional effects. He shows that under ideal circumstances it is possible to wring equal efficiency from any of the instruments discussed, but with widely varying distributional implications.

Another familiar policy demarcation, more explicitly climate-oriented, is between those policy instruments focused on *mitigation* (of greenhouse gas (GHG) emissions), and those focused on *adaptation* (to the effects of climate change), often with finer-grained subdivisions within each category. The bulk of scholarship focuses on mitigation-related policies, often examined in conjunction with the C&C/economic distinction to construct more elaborate policy taxonomies. Nelson et al. (2015) zero in on mitigation policies, for instance, derogating the use of traditional regulatory instruments for GHG reduction as "competitive" policies that increase intergovernmental conflict between state and federal authorities, and advocating instead for more "cooperative" and "coordination" policies, involving cost sharing and other enabling mechanisms.

Pacala and Socolow (2004) introduce the concept of climate "stabilization wedges," describing a portfolio of different policy instruments that could be utilized together to achieve meaningful GHG mitigation, essentially picking off the low-hanging fruit (in cost-benefit terms) before proceeding to more difficult and marginal improvements. They list fifteen different strategies, grouped into categories as energy efficiency and conservation measures, fuel shifting (from coal to natural gas and nuclear), carbon capture and storage (CCS), renewable energy generation, and forest management. Socolow later revisited and slightly redefined the concept (Socolow and Glaser 2009), as have other scholars (Davis et al. 2013). Analysts at consulting firm McKinsey and Co. have elaborated on the concept, by constructing (Auclér and Enkvist 2009) and updating (Enkvist, Dinkel, and Lin 2010) an "abatement cost curve" of over 30 different stabilization wedges, ranking and graphing them according to cost-effectiveness as compared to business-as-usual (BAU), but otherwise avoiding any specific policy or regulatory prescriptions. In an even broader "catch-all" approach, the nonprofit Project Drawdown

(Hawken 2017) has engaged a host of experts to review and publicize a suite of scores of disparate climate change abatement strategies, albeit categorized somewhat eclectically by sectors both economic (e.g., "energy," "transport") and social (e.g., "buildings and cities," "women and girls").

All of these environmental and climate policy assessments and taxonomies differ in their details, but they often have features in common. However broad or narrow the strokes, they tend to be preoccupied with traditional criteria of policy analysis, notably measurements of effectiveness and economic efficiency, with some occasional attention spared for distributional equity. Calculating and comparing these criteria often involves generalizing from real-world instances of policies that have only been implemented or attempted in specific and limited geographical or political settings, or that otherwise do not match theoretical assumptions. Nevertheless, the literature is not shy about arguing fine-tuned technical distinctions among different policy prescriptions.

1.1.2 Political Dynamics

These nuanced distinctions may matter more to scholars than to others. Contemporary American policymaking takes place in a context of political attitudes and incentives, among both policymakers and the general public, that vary dramatically based on factors not related to the substantive merits of actual policies. Given the information constraints on human information gathering and comprehension, stakeholders and other individuals instead form their preferences based on motivated reasoning, driven by broader perceptions of political identity and cultural values, all socially constructed and filtered (Wildavsky 1987). Among the contributing factors to these socially constructed preferences are risk assessments and cost-benefit calculations that might generously be described as “intuitive,” resulting in inconsistent attitudes toward complex challenges, such as poverty, health care, terrorism… and climate change (Sunstein 2007).

These are longstanding characteristics of public opinion, but their effects are exacerbated today by very strong ideological polarization. While there is widespread agreement that ideological polarization has increased over the past generation, there is less agreement on exactly how to define the phenomenon, beyond an increased alignment between partisan identity and political positions. Some scholars observe actual policy preferences among the mass public becoming more extreme (Abramowitz and Saunders 2008), while others contend that the median voter remains centrist and all that has occurred is increased partisan sorting (Fiorina and Abrams 2008; Levendusky 2009). Iyengar, Sold, and Lelkes (2012) attempt to smooth over this conflict, defining polarization as increasing social distance between parties—animosity toward the opposition as an outgroup—independent of positions on specific issues, which may fluctuate. Still others argue for a more complex phenomenon, with elites both influencing and responding to mass attitudes. For instance, Carsey and Layman (2006) find party identification and issue positions to be interdependent, with the direction of influence between them depending on other factors such as salience, the result being that both the parties and the electorate continue to grow increasingly divided on all major policy dimensions (Layman, Carsey, and Horowitz 2006). They elaborate on this phenomenon (Layman et al. 2010) with the finding that party activists with extreme views encourage candidates to adopt similar positions, from which they derive electoral advantage and thereby provide ideological cues to other party loyalists, expanding the domain of inter-party disputes in a process of “conflict extension.” Political elites therefore find it strategically beneficial to identify and seize on “wedge issues” in order to segment public attitudes and mobilize supporters.

Fine points of causal vectors notwithstanding, the effects are clear—polarization both negatively impacts government's ability to act on policy problems, and increases the disconnect between strongly motivated public opinion and substantive policy considerations. Sinclair (2009) shows that heightened polarization has significantly decreased legislative productivity in Congress, especially in the Senate (where the rules prioritize minority-party rights), primarily through the use of procedural roadblocks such as the filibuster. Hence, the strategic imperatives of "conflict extension" obstruct action even on what appear empirically to be policies that would garner broad support on the basis of criteria such as effectiveness or efficiency. As ideology and party identity align more closely, elected officials seeking ideological congruency with their constituents find rewards for forging bipartisan legislative consensus diminishing, while strategic incentives to highlight conflict with the opposing party increase.

The carbon tax provides a clear example. A carbon tax is an instrument designed to recapture a negative externality, the "social cost of carbon," and impose that cost on emitters of GHGs in order to reduce emissions. Nordhaus (2007) celebrates the carbon tax for a whole host of reasons, including economic efficiency, ease of implementation and compliance monitoring, flexibility, and more. Goulder and Parry (2008), in a broader assessment of environmental policy instrument choice, hail and recommend the carbon tax for efficiency reasons, undeterred by questions of political feasibility, which they define away as a function of the distributional impact on organized stakeholders. Metcalf and Weisbach (2009) advise a national revenue-neutral carbon tax regime with an independent rate-setting authority, and a system of border taxes to prevent leakage, calculating that it would be both effective and cost-effective, with no regard for the political resistance such a proposal would engender. Despite all the formidable expertise supporting it, however, the unfortunate fact is that like other tax-based policy instruments, the carbon tax's prospects in today's political climate are all but nonexistent—"tax" has been redefined as a four-letter word not just in Congress, but in legislative chambers around the country (Himelfarb 2011; Kallbekken, Kroll, and Cherry 2011).

A generation ago, market-based environmental policy instruments cut across the partisan ideological divide and were able to win broad support, as with the emissions-trading-based acid rain control program built into the 1990 Clean Air Act Amendments (Stavins 2003), but that is no longer the case; they have fallen prey to strategic conflict extension. Strong ideological polarization is now evident in current attitudes toward almost all kinds of climate policy options, and indeed toward the very fact of climate change itself. Making accurate information available to the public has not been sufficient to stem measurable declines in public belief in the phenomenon (Marquart-Pyatt et al. 2009). In fact, increased scientific literacy can actually be correlated with increased *skepticism* about climate change under some circumstances, especially among more educated Republicans, as once empirical claims become infused with antagonistic cultural meanings, additional information operates to increase polarization between worldviews (Kahan et al. 2012). Gromet, Kunreuther, and Larrick (2013) show that Americans who self-identify as more politically conservative are less likely than others to favor investment in energy efficiency, and indeed are less likely to purchase an energy-efficient light bulb when it is labeled with an environmental message, even with no difference in price. Wendling et al. (2013), in a survey of public opinion in Indiana, find that a plurality of respondents prefer "more research" (50%) over "immediate action" (38%) on the issue of climate change, even though a strong majority (85%) shows at least moderate belief in anthropogenic climate change as a phenomenon.

1.1.3 Geoengineering as an Outlier

It is broadly true that partisan ideological polarization is a strong driver of public attitudes on climate change and the related policy domain, with empirical claims on the issues having become suffused with antagonistic political meanings. However, researchers in the Cultural Cognition Project (CCP) at Yale have found an exception to this pattern (Kahan, Jenkins-Smith, and Braman 2011; Kahan et al. 2012, 2015). That exception is geoengineering.

CCP researchers have developed what they call the Cultural Cognition Thesis, positing mechanisms through which individuals' cultural and political values drive the perceptions of risk that motivate policy preferences across a variety of issues. They underscore that not all risk-related policy issues fall prey to polarization and become ideologically laden in the same fashion as climate change, and that effective public communication must therefore engage two different channels simultaneously—both information content and cultural meaning. In the climate context in particular, they have found experimentally (Kahan et al. 2015) that making citizens aware of geoengineering as a means of GHG mitigation appears to offset polarization over both the validity of climate change and potential responses to it, eliciting more open-minded attitudes. They posit that in contrast to a traditional regulatory approach involving a strict ceiling on emissions, perceived by many subjects as antagonistic to business and technology and involving sacrifices (e.g., changed consumption habits) for uncertain long-term gains, the concept of geoengineering triggers more upbeat perceptions, symbolizing the ability of humanity to innovate new technologies that solve problems and overcome current limits. Other studies suggest complementary logic; e.g., Cummings and Rosenthal (2018) identify several criteria contributing to public opinion formation on geoengineering, including topic familiarity, epistemic trust in science, and preference for alternative solutions to climate change.

Precisely because of the relatively low salience of geoengineering in public discourse, a brief review of the subject is in order to clarify what sets it apart from other kinds of policy instruments. Geoengineering (sometimes also referred to as "climate engineering") is a broad-umbrella term referring to an array of technologies designed to manipulate the environment, on scales ranging from local to global, in order to offset the harmful consequences of climate change. As such, it does not fit tidily into traditional policy taxonomies. The portfolio of approaches involved, some tested and some as yet hypothetical, includes options that may fit or resemble different aspects of other taxonomies—e.g., they can be subdivided into techniques focused on post-emission *carbon dioxide removal* (CDR, more analogous to mitigation) and those focused on *solar radiation management* (SRM, more analogous to adaptation) (Shepherd et al. 2009). Heyward (2013) proposes situating CDR and SRM in the middle of a five-stage climate policy typology, respectively closer to (but still not identical with) mitigation and adaptation. The analogies are loose, however, and geoengineering is fundamentally different, in that it focuses primarily on achieving climate stabilization by counteracting harmful effects from GHG emissions that have already happened. It is also distinct from the traditional C&C vs. MBI dichotomy, as many of the techniques involved do not require either mandating or incentivizing any behavioral change. The term was coined in the late 1970s (Schneider 2008), and within a few years Schelling (1983) was suggesting that geoengineering might offer a more cost-effective and/or politically palatable response to climate change than taxing emissions or switching away from fossil fuels.

An independent study conducted for the Royal Society (UK) and its follow-up (Shepherd et al. 2009; Shepherd 2012) offer a clear taxonomy of geoengineering techniques that has been followed by many subsequent scholars, defining CDR as techniques that enhance CO_2 uptake and storage (explicitly disregarding other GHGs), including biological systems (either terrestrial, such as afforestation, or oceanic, such as iron fertilization) and engineered systems (atmospheric scrubbers, ocean alkalinity enhancement), while defining SRM as techniques that increase solar deflection or reflection, including surface-, cloud-, upper-atmosphere-, and space-based systems. Shepherd assesses all of these on criteria of effectiveness, affordability, timeliness, and safety, finding that in general CDR techniques operate more slowly while SRM is faster, and that stratospheric aerosols score best on the first three criteria but also carry the highest risk of unpredictable side effects on the biosphere, such as ozone depletion and/or reduced precipitation. He notes that "The acceptability of geoengineering will be determined as much by social, legal and political issues as by scientific and technical factors" (Shepherd 2012, 4173), and advises extensive research and development (R&D), as well as intergovernmental oversight agreements, before large-scale deployment. In the meantime, scholars in the UK (Pidgeon et al. 2012) have reached findings similar to those of Yale's CCP team about public openness to geoengineering concepts.

While geoengineering technologies do not by themselves promise any silver-bullet solution to the long-term threat of climate change, optimistic public perceptions notwithstanding, they do offer an additional array of stabilization techniques beyond those routinely considered and debated. It is also noteworthy that some geoengineering techniques can be implemented effectively by subnational authorities rather than requiring action from national governments, and indeed (although this poses risks as well as benefits) can be deployed at various scales through public-private partnerships with relatively little direct government involvement of any kind.

Of course, as public awareness and the salience of the topic increase, it is possible that organized interests may impose narrative frames that impact the political viability of geoengineering, in part or in whole. Thus far, Anshelm and Hansson (2014) find "four coherent storylines" that recur in the framing of geoengineering for public consumption (based on a broad content analysis of mass media content on the subject, spanning 2005-2013 and including several sources from non-English-speaking countries). They describe these narratives as "scientists' double fear," in which both climate change and geoengineering have high-risk stakes, but the former risks make the latter worth taking; "the price of political failure," risks notwithstanding, in which geoengineering emerges as our last best hope, since international political negotiations have stalled and BAU economic growth seems inevitable; the "bridge to a sustainable future," a view infused with technological optimism, in which geoengineering is humanity's "plan B" to buy time for a more orderly transition away from GHG-generating fossil fuels; and an exercise in "just mimicking nature," with the eco-pragmatic attitude that all natural systems are already compromised, and we are merely seeking to engineer corrective mechanisms like those found in nature itself, except with fewer negative ramifications for humanity.

While these four narratives vary in their levels of risk aversion, their balance of cynicism versus optimism, and their framing of geoengineering as a necessary evil versus a good in itself, it is noteworthy that all four treat geoengineering as substantially depoliticized—perhaps related to the way its discourse to date has been dominated by scientists and engineers. In a recent overview of the scholarship, Zhang et al. (2014) find most research to date focused narrowly on the physical science aspects of geoengineering, excluding much detailed consideration of legal or social policy implications. Among the few exceptions are Bellamy et al. (2012), who note the limitations of supposedly normative governance frames and emphasize the important of citizen participation in evaluating policy options, arguing that "the narrowly framed considerations of performance and risk offered by traditional technocratic expert-analytic methods of appraisal (and some participatory ones as well) and the predictive governance that they support cannot therefore account for unanticipated evolutions in geoengineering" (Bellamy et al. 2012, 612).

1.1.4 Inequality and Representation

If it is true, as observed above, that public opinion is not necessarily tightly linked to the merits of actual policies and proposals, it is also true that policy enactment is not necessarily tightly linked to public opinion. While the relationship between public opinion and policymaking is central to our concept of democratic accountability, for many years this influence was largely taken for granted, rather than being subjected to in-depth study (Shapiro 2011). Once scholars began to examine the question in earnest, the conclusions were wide-ranging and ultimately indeterminate, constrained by imperfect data, analytical boundaries, and a bewildering assortment of other variables. Even a recent finding that policy outcomes in the states are "highly responsive" to policy-specific opinion still concludes that policy is congruent with the will of the majority only half the time (Lax and Phillips 2012). While it seems fair to say that public support is not entirely unrelated to any given policy's prospects for enactment, then, in itself it is neither necessary nor sufficient to achieve that goal.

In particular, multiple threads of research now show that above and beyond the effects of polarization, as already discussed, another key dilemma in contemporary American policymaking flows from increasing levels of economic inequality, which have produced corresponding increases in representational inequality (Bartels 2008; Hacker and Pierson 2011; Gilens 2012; Gilens and Page 2014; Gilens 2015). Analyzing a wide variety of policy cases and testing them against competing strains of democratic theory, Gilens and Page (2014) find that where public preferences are concerned, the United States does not have a broad majoritarian democracy, in which policy outcomes chiefly reflect the collective will of ordinary citizens, but instead what they term *"economic-elite domination,"* in which individuals with high levels of income or wealth exercise a dominant influence on policy choices. Moreover, looking beyond individual actors to the struggle for influence among organized interest groups, policy entrepreneurs, and other institutional actors, this country does not have majoritarian pluralism, a "polyarchy" in which a wide diversity of interests is represented, but rather *"biased pluralism,"* in which the interests of corporate, business, and professional groups exert a dominant influence. The political viability of any given policy proposal—its likelihood of rising on the agenda and being enacted and implemented—therefore rests in the hands of interested elites, whose preferences may or may not coincide with those of the broader public.

Gilens (2012) also observes that factors such as weak campaign finance laws and increased partisan gerrymandering contribute to the problem of economic elite influence by reducing electoral competition for incumbents, whereas greater electoral competition "increas[es] the incentives for candidates to appeal to all voters" (Gilens 2012, 250), rather than just affluent donors and/or copartisans. Donor affluence and gerrymandering thereby intersect and exacerbate both obstacles to policy formation under consideration here—polarization, as discussed above, as well as representational inequality.

These findings on unequal representation cast doubt on the political relevance of the research indicating certain categories of climate policy options (specifically geoengineering) are significantly less susceptible to political resistance from the public. They argue forcefully that public attitudes alone are neither necessary nor sufficient for policy enactment. Seen in this context, the challenge of finding or designing politically viable climate policies compels us to look beyond the mass public and examine specifically *elite* opinion.

1.1.5 A Compound Challenge

When considering the political viability of policy instruments and designs to deal with the threats posed by climate change, therefore, we are faced with two sets of complications, the one compounding the other. First, it is not enough to compare policy options on the basis of empirical criteria such as effectiveness or efficiency; they must pass through the filter of polarization, which produces public attitudes that may be unrelated to the apparent empirical merits of a proposal. Second, when assessing those attitudes, it is not sufficient merely to look to broad-based public opinion, since that is by no means the determining factor in policymaking. In short, the complications imposed by both polarization and inequality make it necessary to look beyond not just traditional policy analysis criteria, but also beyond traditional public opinion metrics, in order to find a path to real-world climate policy solutions. That is the challenge motivating this research.

Geoengineering provides fertile territory in which to examine these questions, and perhaps to find that path. While it shows promise where public opinion is concerned, the reactions of economic elites remain to be examined. My provisional expectation from the outset of this dissertation has been that elite opinion on these policy instruments would indeed mirror that of the broader public. Insofar as polarization is driven by elite cues on strategically useful issues (Layman et al. 2010), it stands to reason that if interested elites saw geoengineering as a promising wedge issue, they could and would have made it so already. It is reasonable to infer that elites do not want to do so—or to speak more precisely, that they have found no incentives to do so, and therefore that they remain open to the possibilities themselves. Future incentives may shift, and attempts to reframe and politicize the topic are always possible (as happened in the past with “cap-and-trade” policies, for instance), but for the time being the path forward should be relatively clear of obstacles.

1.2 Overview of Dissertation

In this dissertation I operate in the territory where policy studies and political science intersect and complement one another, undertaking to examine climate policy alternatives in light of political dynamics, and climate politics in the context of the search for effective policies. Political viability is a daunting filter through which to approach any policy domain, and certainly one as complex as climate change, and in operationalizing that filter I also navigate the intersection of two distinct and usually independent strands of literature on political constraints, respectively concerning the effects of ideological polarization and economic inequality.

Through this project I thereby integrate and expand upon existing research by analyzing the effects of partisan identity and economic status, in both individual and institutional forms, as boundary conditions defining political viability for climate policies in general, and geoengineering more particularly.

The challenge of identifying politically viable climate policies, as described, leads me to pose three carefully focused questions. Firstly, in light of the relative dearth of national-level climate policy in recent decades and the consequent burden on subnational actors, I ask what kinds of factors have driven state-level climate policy adoption, examining both objective statistical findings and the subjective experience of relevant state-level policy actors. Secondly, stepping from retrospective enactments to prospective possibilities, I ask whether the attitudes of economic elites reflecting existing scholarly findings about the mass public, using survey data to evaluate attitudes toward climate change and geoengineering. Thirdly, looking beyond individual attitudes to the behavior of influential institutional actors, I ask about the extent to which geoengineering-related initiatives garner support from such actors, identifying and evaluating real-world case studies. I entered into this dissertation hypothesizing that all these lines of inquiry would point toward political viability for geoengineering-related climate policy initiatives at levels significantly higher than for traditional regulatory approaches.

Chapter One of this dissertation has limned necessary background information on climate policy in general, political obstacles to climate policy formation, geoengineering, public opinion, polarization, inequality, and representation. The following chapters contain the substantive body of the dissertation—each focused on one research question, discussing additional relevant literature, defining relevant terms and variables, and describing the methods by which I have pursued this inquiry. Each chapter engages its motivating question with a different methodological approach, and each can stand on its own as an independent article of research, but they relate to and complement one another in a way designed to exceed the sum of the parts.

Chapter Two investigates the process of state-level adoption of innovative climate related policies. The approach is multi-method, sequentially quantitative then qualitative. The first component involves updating and replicating some of my own published collaborative work (Carley and Miller 2012), a statistical event-history analysis (EHA) of state-level policy diffusion, as a guide to the political factors influencing past policy adoptions. The second component is qualitative and normative, employing semi-structured interviews with a selective sample of state-level policy actors, comparing and contrasting their experiences with theoretical findings. Together, they provide an empirical jumping-off point for the chapters that follow.

Chapter Three investigates the attitudes of individual economic elites, which have been shown to dominate the political behavior of policymakers. The approach is quantitative, using data gathered through a customized survey experiment and evaluating it with both parametric and nonparametric modes of analysis to determine elites' degree of openness to climate change information, and to policy interventions in a geoengineering context.

Chapter Four investigates the revealed preferences of elite (business and industrial) organized interests, as seen through their support for specific geoengineering research programs and policy initiatives. The approach is mixed-method, employing qualitative comparative analysis (QCA) to interpret a limited set of case studies and underlying conditions.

Chapter Five concludes the dissertation, including a summary review of the findings, consideration of theoretical contributions, discussion of methodological challenges and limitations, and final thoughts. As a whole, this work provides three angles of approach to the challenge of identifying politically viable climate policies. Taking explicit account of political viability could allow scholars and policymakers to shift greater attention to policies that—even if not strictly optimal according to the usual scholarly criteria—could do more to address climate change than alternatives that remain perpetually on the drawing board. It demonstrates a path that skirts conventional political obstacles, potentially triangulating on geoengineering as a prospective solution domain, and in the process provides a foundation for a longer-term research agenda.

2 SUBNATIONAL FACTORS AND SUBNATIONAL ACTORS

2.1 Background

The unit of analysis for climate policy analyses is often the federal government, specifically Congress—in its own capacity as a policymaking agent, or as a party to even larger-scale international agreements. Chapter Three of this dissertation certainly focuses on national policy, at least as an object of public opinion. Chapter Four branches out from that; the case studies it examines operate at a variety of levels, although a recurring concern is the extent to which they could be scaled up to the level of national policy. However, subnational activities and policy actors are also relevant in their own right, and indeed must be understood as a foundation for assessing the potential for future climate policies.

First, new policy innovations are often tried first at the state level, as noted in the memorable phrasing of Justice Louis Brandeis (*New State Ice Co. v. Liebmann*, 1932): "It is one of the happy incidents of the federal system that a single courageous State may, if its citizens choose, serve as a laboratory; and try novel social and economic experiments without risk to the rest of the country." This can include state efforts at comprehensive reform (within the boundaries of federalism and potential conflicts of laws) such as California's Global Warming Solutions Act of 2006 (AB-32 2006), a cap-and-trade system that closely complements the sort of state-level initiatives examined in this chapter, or even voluntary intergovernmental compacts such as the Western Climate Initiative (WCI 2020), in which California partners with two Canadian provinces, or the northeast's Regional Greenhouse Gas Initiative (RGGI 2020).

Second, many of the geoengineering policy options under discussion in this dissertation are more easily scalable than traditional national- or global-scale climate policies, and could plausibly be deployed effectively by geographically smaller institutions even without being part of a national policy regime.

Still, without question, state policymakers must contend with many of the same influences, pressures, and constraints as national ones. Institutional inertia tends to preserve policy equilibria based on existing balances of power (Baumgartner and Jones 2009). In the present chapter, therefore, I give closer consideration to the factors driving climate policy at the state and local level, as preface for exploring whether those factors may indicate support for geoengineering initiatives at that level.

In Section One of this chapter, as a preliminary step, I begin the inquiry by revisiting and updating previous research on political determinants of climate policy adoption, to confirm they are robust with respect to recent developments in the literature. This is a purely quantitative exercise. In Section Two, I build on that foundation with a qualitative approach, exploring the insights of individual state-level policy actors to determine the extent to which their experiences correspond to the findings and predictions of this research.

2.2 Research Question(s)

Past studies indicate that state-level adoption of climate-related energy policies is strongly influenced by state-level political ideology, at either (or both) the government and citizen level. Does statistical analysis incorporating improved metrics replicate these findings? Does the experience of relevant state-level policy actors reflect these limits on (or opportunities for) policy action? What patterns emerge from these actors' perceptions of the political viability of climate policies?

2.3 Review of Relevant Literature

Climate and energy policy concerns arise from a triad of interconnected issues. Climate change itself, first and foremost, is driven primarily by greenhouse gas (GHG) emissions from the combustion of fossil fuels, widely used for energy production. A second area of concern, relevant both to policymakers and to potentially influential policy entrepreneurs, is economic competitiveness, affected by the increasing extraction costs of fossil fuels and by the profit potential of emerging markets for renewable energy (RE). A third consideration is energy "security," as lawmakers at both national and subnational levels seek to diversify (or otherwise secure) their energy supplies and thereby reduce vulnerability to market shocks.

From the 1990s forward, most state-level policy initiatives related to climate change have focused on energy sustainability. Stepping into the policy vacuum left by the relative dearth of national-scale policies in this domain over the past 30 years, states have adopted a wide variety of innovative policy instruments (Rabe 2008). Prominent policy models include net metering (NM) and energy efficiency resource standards (EERS), among other attempts such as direct carbon taxes, marketable greenhouse gas allowances, or state production incentives. However, the most popular has been the renewable portfolio standard (RPS), a policy design that diffused widely across the country by 2010 (Carley and Miller 2012).

The RPS is a compound policy design incorporating incremental thresholds for levels of renewable energy generation (e.g., wind, solar, geothermal) to be met by specific target dates. The RPS has proved to be a remarkably popular policy model throughout the United States, adopted far more widely than alternatives (Wiser, Porter, and Grace 2005; Rabe 2008). As of 2010, some form of statewide RPS had been adopted in 35 states (North Carolina Clean Energy Technology Center 2020), 17 of those enacted just since 2005. That number had changed only slightly by 2020 (although many of the policies have been revised or updated in the intervening years), as only three additional states have implemented any form of RPS policy in the years beyond the scope of this project's dataset: Oklahoma in 2010, Indiana in 2011, and South Carolina in 2014 (NC Clean Energy Technology Center 2020). Interestingly, Indiana's policy is uniquely toothless in that it is not only completely voluntary, but also lists a wide range of conventional energy sources including coal and natural gas as acceptable "clean" energy sources.

As that example demonstrates, the precise details (and levels of stringency) of RPS policies vary considerably from one implementation to another. There are no uniform policy design criteria. Wiser and Barbose (2008) provide a thorough overview of RPS policy design variation; for example, among other differences, any given RPS may or may not include:

- Specific technologies either prohibited, allowed, or mandated;
- Sourcing requirements, whereby some or all renewable power may be required to be generated within the state;
- Exemptions for selected energy producers, such as municipally-owned utilities;
- Tradable RE credit markets, either in-state or within regional boundaries, whereby a state can satisfy a portion of its RPS requirements by purchasing these credits from renewable energy power producers;
- Monitoring and enforcement mechanisms, ranging from strict mandates with compounding financial penalties to completely voluntary regimes with no compliance requirements whatsoever.

Notwithstanding these variations, the RPS has remained a consistently popular policy mechanism, in comparison to other alternatives. Indeed the very flexibility of the policy model, some argue, is among the features that facilitates its wide adoption (Karch 2007; Rabe 2008).

However, studies offer nothing resembling a consensus on the effectiveness of RPS policies, by any metric (e.g., Rabe 2008; Wiser and Barbose 2008; Carley 2009; Yi 2010; Yin and Powers 2010).

There has also been substantial disagreement about the factors, both internal and external, that lead states to adopt innovative new policies like these. Some policy decisions appear to be driven primarily by determinants internal to a state—for example, matters of economics, demographics, political capacity, or citizen ideology—while others arise as the result of policy diffusion from other states (Walker 1969), the phenomenon whereby an innovation originating in one locale later spreads to others. The pattern of policy adoption scholarship in political science was set by Berry and Berry (1990), who pioneered the technique of event history analysis (EHA)—tracking events using a "state-year" as the analytical unit, accounting for both internal and external determinants within a single model.

Despite otherwise inconsistent findings, however, one factor multiple scholars *have* found to have significant positive correlations with policy adoption is state political ideology, operationalized in terms of both citizen preferences and state government orientation (Huang et al. 2007; Matisoff 2008; Stoutenborough and Beverlin 2008; Chandler 2009; Lyon and Yin 2010).

Some revealing relationships may have been obscured by the fact that much RPS adoption literature has treated policy adoption strictly as a binary dependent variable, neglecting to account for the policy design variations noted above. Logically, there may well be a meaningful different between the policymaking process in a state that chooses to adopt a stronger RPS, versus one that adopts a policy that is weaker or completely voluntary. In that vein, prior research in which I collaborated (Carley and Miller 2012) devised an indexed metric of policy stringency that is able to differentiate state RPS policies into four categories: strong, weak, voluntary, or none. An EHA on such a dependent variable can be conducted using a multinomial logit regression (MNL), with “no RPS” held as the omitted baseline category against which others are compared. Conducting this analysis produced the interesting finding that citizen ideology is a highly statistically significant factor for adoption of RPS policies in general, but when those policies are disaggregated into voluntary, weak, and strong categories, citizen ideology is significant only for the first two categories. The strongest RPS policies, however, are predicted not by indicators of citizen ideological liberalism, but instead by *government* ideological liberalism.

This is consistent with expectations derived from studies of ideological polarization and representation (e.g., Layman, Carsey, and Horowitz 2006); one might reasonably expect government ideology to have at least as direct a bearing on policy decisions as citizen ideology. It seems plausible that policymakers’ choices may be motivated by the extent to which a weak policy design can nominally satisfy constituents’ preferences by functioning as symbolic politics, whereas policymakers operating in a clear liberal political context (or with a clear ideological commitment of their own) are more likely to craft more ambitious policies. Put another way, it appears that at least in the domain of climate and energy policy, legislative partisanship and/or ideology may have more to do with the success of substantively ambitious policy proposals than anything involving public preferences.

More recent literature offers further confirmation of such findings, and invites a broader approach: e.g., Bromley-Trujillo et al. (2016) find state political ideology a primary driver of policy adoption across 14 different climate policy options. These findings are entirely compatible with the concept of economic elite influence dominating the policymaking process (e.g., Gilens and Page 2014), as examined in Chapter Four of this dissertation. It is noteworthy, after all, that an elite actor need not have invested, contributed, or lobbied on behalf of a particular project or policy to exert influence… supporting the status quo or a less-stringent alternative can also be significant, especially to ideologically sympathetic policymakers, given the wide range of veto points in the American legislative system (Jones and Levy 2007). For instance, the distribution of model environmental statutes by the corporate-dominated American Legislative Exchange Council (ALEC) to state governments (especially those dominated by the GOP) has posed a significant obstacle to progress on environmental policy in many such states, even when ALEC is at odds with public opinion—and indeed sometimes at odds with major corporations, some of which have severed ties with ALEC over its stance on environmental and climate issues. (Trapenberg Frick, Weinzimmer, and Waddell 2014; Henry 2015; Westervelt 2015).

However, the Carley and Miller (2012) work bears revisiting in light of recent scholarship on the political metrics involved. State-level political ideology is historically difficult to measure, and that study utilized the least-problematic metrics available at that time, the Berry/Ringquist/Fording/Hanson composite indices of both citizen and government ideology (Berry et al. 1998; 2007; 2010), as detailed further below. Since publication of that work, however, new dynamic models have emerged for both state citizen ideology (Caughey and Warshaw 2015; 2018) and state government ideology (Caughey and Warshaw 2016) that promise improved construct validity, covering a broader range of policy domains over a longer span of years, drawing when possible on polls rather than proxy measures, and incorporating a very wide array of indicators of policy liberalism, all in order to reduce measurement error on the latent constructs. (Enns and Koch (2013) also introduced a competing metric, but Berry et al. (2015) have cast considerable doubt on its validity.)

In the interest of acknowledging and resolving the challenge this poses, in Section One of this chapter I replicate the 2012 study incorporating revised models of state political ideology, based on the Caughey and Warshaw models, and compare the results to the original analysis, both for a binary dependent variable (policy adoption irrespective of stringency) and for the multinomial logit EHA. I have undertaken this exercise expecting the updated analysis to be consistent with the original findings and the corroborating literature, but potentially to reveal new insights. At the very least, it provides a robustness test.

Additionally, it is worth wondering to what extent similar logic might apply (prospectively) to the political viability of geoengineering policy proposals, which do not as yet have a (retrospective) track record of adoption or diffusion across the states. What obstacles (or resources) have policy actors "on the ground" encountered in relation to past climate initiatives, and in what ways do those experiences corroborate or inform our analytical understanding of the processes involved in the future? To address that question, in Section Two of this chapter, I conduct semi-structured interviews with selected subnational policymakers, and offer qualitative analysis of the experiences they recount.

Section One

2.4 Research Approach, Data, and Methodology

As a foundational step, I have revisited the analysis from the previously published work (Carley and Miller 2012) on the political determinants of climate-related energy policy adoption, specifically RPS policies. I have replicated that study incorporating additional data and revised models of state political ideology, and compared the results to the original analysis, both for a binary dependent variable (policy adoption irrespective of stringency) and for the multinomial logit event history analysis (EHA). As a validity check, I also analyzed the probability of RPS adoption using a complementary log-log distribution (as advocated by Buckley and Westerland (2004)), since this distribution has a steeper slope and is better able to handle the rare-event nature of policy adoption.

The study draws on a data set covering 49 U.S. states over a twenty year span, 1990-2009. Data on state RE policy are public information, and are compiled on an ongoing basis in the Database of State Incentives for Renewables and Efficiency (DSIRE) maintained by the North Carolina Clean Energy Technology Center (formerly the North Carolina Solar Center) at North Carolina State University (NC Clean Energy Technology Center 2020). The study employs a multinomial logit EHA incorporating several theoretically relevant covariates, with a categorical dependent variable representing adoption of an RPS at a given stringency level. Given the methodological logic of an EHA, it is necessary to drop all observations for a given state for those years following its adoption of an RPS policy. The final sample size is therefore 814 observations. (The original published paper ends the data set in 2008, for a total of 796 observations.)

The stringency calculation incorporates multiple essential components of policy stringency—the prorated average annual level of change in share of energy production mandated from RE sources, multiplied by the percentage of a state's electrical load that is actually covered by the RPS regulation. This approach avoids the risk of spurious fluctuations in stringency in response to exogenous influences, and provides a single more comprehensible number that can be compared against the policies of other states. The stringency index is calculated as of the time of initial policy adoption. The theoretical maximum stringency is 10,000, representing a hypothetical super-ambitious state moving from zero to 100 percent renewable energy in the space of one year, but actual observed stringency levels cluster in a range somewhat below 100. To determine a cutpoint between weaker and stronger policies, the study employs a primary model that takes the stringency level for a given state's RPS at the time of adoption (i.e., for a state-year), and compares it against the median stringency of other states that have adopted a policy as of that year. This calculation produces a year-to-year rolling threshold that reflects the evolving state of the policy environment, making it possible to divide states into categories according to their stringency relative to that threshold.

The final version of the dependent variable, *RPS scale*, is coded as follows:

- 0 if the state has no RPS policy;
- 1 if the state has a voluntary, non-binding policy;
- 2 if the state has a weak RPS, and;
- 3 if the state has a strong RPS.

The independent variables in the analysis are those found to be significant or theoretically relevant for energy and environmental policy by existing state-level policy adoption studies that did *not* account for variations in policy strength (Ringquist and Garand 1999; Huang et al. 2007;

Matisoff 2008; Stoutenborough and Beverlin 2008; Chandler 2009; Lyon and Yin 2010; Wiener and Koontz 2010). They include metrics for renewable energy potential, electricity price and deregulation, neighboring states with similar policies, population growth rate, state affluence, and a year trend (to account for the increased likelihood of policy adoption over time), as well as political factors including state-level citizen ideology and state-level government ideology.

Both citizen and government liberalism (using the term “liberalism” not as understood either colloquially or by philosophers, but as a measurable characteristic defined by the literature) stand out as crucial independent variables in the original RPS study, but state-level political ideology has always been difficult to measure, given the shortage of routine comprehensive polling of the kind available at the national level. As a result, it is commonly operationalized using broad-brush proxies, such as partisan legislative control—which, given its binary character, often indicates much more volatility than is logically plausible. The least-problematic metrics available as of the original study, in 2012, were the Berry/Ringquist/Fording/Hanson (BRFH) indices (Berry et al. 1998; 2007; 2010), complex models incorporating and weighting multiple factors, including interest-group ratings of Congressional representatives, estimated ideologies of electoral challengers, vote weights by district, and a non-linear distribution of legislative partisanship, deriving a result indexed on a sliding scale of policy liberalism ranging from 0 to 100.

In the intervening years, however, improved metrics have emerged, better reflecting changes in state politics over time while relying on fewer proxies. Caughey and Warshaw (2016) offer a dynamic model of state-level governmental policy liberalism that includes 148 policy outcomes, spanning eight decades and a wide range of policy domains, using a dynamic Bayesian latent-variable model to accommodate a mix of continuous, ordinal, and dichotomous policy indicators while minimizing measurement error. Caughey and Warshaw (2015, 2018) similarly offer new measures of state-level citizen liberalism as expressed in mass preferences (both overall and disaggregated into social and economic policy domains), using a dynamic hierarchical item-response model drawing on decades of public opinion surveys. Caughey and Warshaw demonstrate superior construct validity for each of these new metrics.

(Although one might be tempted to suspect some degree of endogeneity between citizen and government liberalism, in fact they have little or no systematic correlation. Among the reasons for this are electoral geography (Jusko 2014; 2015), in that citizen populations are distributed very differently from electoral districts—and for that matter interest groups—serving to dilute the impact of public opinion by weakening the connections both between voter policy preferences and candidate choice, and between electoral success and responsive policy enactment. Another factor is that past state policies act as a powerful confounder, imposing path dependence on future policies even when public opinion shifts. Indeed, when controlling for past state policies, Caughey and Warshaw (2018) find state government policy responsiveness to citizen liberalism not to be statistically significant at all in southern states, and to have very low magnitude even in non-southern states.)

Taking these developments in the literature into account, I have re-analyzed the relevant RPS models utilizing Caughey and Warshaw's metrics for the political variables in place of the BRFH indices. Caughey and Warshaw's (2016) measurements of state government policy liberalism are available for general use; I have converted them from a standardized format (with a mean of zero) to a 0-100 index. Caughey and Warshaw's original (2015) mass public liberalism measurements are not available, as the replication data is proprietary, but the sub-measures divided into social and economic categories (2018) are available, so I constructed variants of the RPS model using each of those individually, as well as a combined average of the two, again on a 0-100 scale.

The overall goal is to determine whether the updated analysis is consistent with the original findings and the corroborating literature, to serve as a foundation for more targeted qualitative inquiries. The re-analysis at least serves as a robustness test, and may also reveal new insights.

2.5 Analysis

Stated succinctly, the goal of the initial part of this study is to test the validity of the factors previously found to contribute to subnational adoption of climate-related policies (specifically RPS policies) that are measurable, statistically significant, and theoretically relevant. While some of the variables involved are nuanced enough that they unavoidably have to be measured with proxies or composite indices, the model has been updated using the best available data, in the hope that a consistent picture will still emerge. My expectation from the outset was that the results would validate the findings of the 2012 study, identifying political factors as dominant—specifically, citizen liberalism for weaker policies, and government liberalism for more stringent policies.

2.5.1 Results

2.5.1.1 Binary

Preliminary analysis of RPS adoption as a simple binary dependent variable, *sans* stringency measures, calls for a logit regression. The results are shown in the tables below. Table 2.1 contains a replication of the analysis from Carley and Miller (2012), as a baseline, with the data set truncated in 2008 and no changes to the independent variables. The statistically significant variables are citizen ideology, as well as the time trend. The complementary log-log analysis, presented in the same table, produces almost identical results, while also showing affluence — measured as gross state product (GSP) per capita—nudging over the line into statistical significance. As expected, citizen liberalism and GSP per capita are both positively associated with RPS adoption.

Table 2.1. Original Model with Binary Dependent Variable: Adoption of an RPS

RPS	**Logit Coefficients**	**Complementary Log-Log Coefficients**
RE potential	7.56×10^{-10}	3.58×10^{-10}
	(8.63×10^{-10})	(7.56×10^{-10})
Percent contiguous states with RPS (lagged)	0.463	0.460
	(0.861)	(0.787)
Citizen liberalism	**0.0783*****	**0.0675*****
	(0.0219)	(0.0194)
Government liberalism	-0.00107	0.00115
	(0.0198)	(0.186)
Percent Democratic in House	0.317	0.0691
	(1.67)	(1.42)
Electricity price	0.0317	0.247
	(0.106)	(0.956)
Deregulated	0.327	0.352
	(0.484)	(0.436)
Population growth rate	24.01	19.62
	(20.71)	(17.77)
GSP per capita	**49.18**	**41.84***
	(30.34)	(25.60)
Year trend	**0.213*****	**0.205*****
	(0.0665)	(0.0609)
Constant	-12.74	-11.62
	(1.91)	(1.62)
Number of observations	796	796

Standard errors in parentheses.
*Statistically significant at the 10% level. ***Statistically significant at the 1% level.

Table 2.2 repeats the same analysis, but updates the data set to include 2009 (adding 18 data points). GSP per capita disappears from the picture, but the results otherwise remain identical to the original.

Table 2.3 updates the model with the Caughey-Warshaw metrics described above for both citizen liberalism and government liberalism. The findings remain the same, although the degree of statistical significance for citizen liberalism subsides from α=0.01 to α=0.05.

Table 2.2. Data through 2009, Binary Dependent Variable: Adoption of an RPS

RPS	Logit Coefficients	Complementary Log-Log Coefficients
RE potential	6.85×10^{-10}	3.94×10^{-10}
	(8.38×10^{-10})	(7.40×10^{-10})
Percent contiguous states with RPS (lagged)	0.848	0.815
	(0.809)	(0.737)
Citizen liberalism	**0.0760*****	**0.0664*****
	(0.0204)	(0.0182)
Government liberalism	-0.00725	0.00839
	(0.0194)	(0.0181)
Percent Democratic in House	-0.214	-0.0358
	(1.63)	(1.39)
Electricity price	-0.00454	-0.00582
	(0.102)	(0.0915)
Deregulated	0.339	0.347
	(0.457)	(0.407)
Population growth rate	13.59	9.57
	(21.19)	(18.79)
GSP per capita	42.91	38.54
	(28.60)	(24.55)
Year trend	**0.1933*****	**0.186*****
	(0.0597)	(0.0542)
Constant	-11.96	-11.10
	(1.76)	(1.54)
Number of observations	814	814

Standard errors in parentheses.
***Statistically significant at the 1% level.

Table 2.3. Data through 2009, Political Variables Updated, Binary Dependent Variable: Adoption of an RPS

RPS	Logit Coefficients	Complementary Log-Log Coefficients
RE potential	2.96×10^{-10}	1.91×10^{-10}
	(8.13×10^{-10})	(7.69×10^{-10})
Percent contiguous states with RPS (lagged)	0.552	0.418
	(0.839)	(0.753)
Citizen liberalism (Caughey-Warshaw average)	**0.122****	**0.102****
	(0.0578)	(0.0519)
Government liberalism (Caughey-Warshaw index)	0.0235	0.0263
	(0.0215)	(0.0202)
Percent Democratic in House	1.42	1.12
	(1.59)	(1.41)
Electricity price	-0.899	-0.0804
	(0.114)	(0.102)
Deregulated	-0.205	-0.162
	(0.497)	(0.452)
Population growth rate	6.35	6.33
	(20.76)	(19.60)
GSP per capita	9.05	7.37
	(30.98)	(28.83)
Year trend	**0.354*****	**0.350*****
	(0.0815)	(0.0772)
Constant	-16.14	-15.00
	(2.80)	(2.46)
Number of observations	814	814

Standard errors in parentheses.
**Statistically significant at the 5% level. ***Statistically significant at the 1% level.

2.5.1.2 Categorical

To draw out more nuanced relationships between variables, the dependent variable is subdivided into categories. This MNL model reflects the likelihood of adopting an RPS at three distinct levels of policy stringency, relative to the reference case of no policy action at all. Both the original analysis, and the replication thereof, show citizen liberalism to be a highly significant indicator for Voluntary and Weak policies, but not for Strong policies, where it is replaced by government liberalism. The time trend is also significant for the first and third categories; as almost always, as time elapses, a state becomes more likely to emulate its fellow states and adopt an RPS rather than maintain no RPS. When I analyzed the same variables but updated the dataset to include the data for 2009, it produced the same results, as shown in Table 2.4, *except* that deregulation and GSP per capita nudge their way into (low-level) significance for Weak policies.

Table 2.4. Data through 2009, Multinomial Logit Model with Dependent Variable Reflecting Stringency (Omitted Category: "No RPS")

RPS Stringency	Voluntary	Weak	Strong
RE potential	$-1.68\text{x}10^{-9}$	$1.18\text{x}10^{-9}$	$1.18\text{x}10^{-9}$
	$(3.01\text{x}10^{-9})$	$(1.23\text{x}10^{-9})$	$(1.20\text{x}10^{-9})$
Percent contiguous states with RPS (lagged)	1.73	-0.459	1.34
	(1.61)	(1.26)	(1.25)
Citizen liberalism	**0.119*****	**0.104*****	0.0296
	(0.0446)	(0.0396)	(0.0271)
Government liberalism	-0.0164	-0.0391	**0.0864****
	(0.0399)	(0.0314)	(0.0387)
Percent Democratic in House	-4.46	1.34	1.33
	(3.32)	(2.62)	(2.77)
Electricity price	-0.0805	-0.145	0.0773
	(0.217)	(0.186)	(0.151)
Deregulated	-1.54	**1.22***	0.661
	(1.27)	(0.705)	(0.698)
Population growth rate	29.75	28.21	-2.54
	(51.47)	(27.37)	(28.86)
GSP per capita	44.71	**74.29***	47.55
	(58.30)	(44.06)	(45.54)
Year trend	**0.310****	0.0651	**0.256****
	(0.152)	(0.0888)	(0.101)
Constant	-13.56	-11.64	-17.66
	(4.31)	(2.44)	(3.67)

Number of observations = 814. Standard errors in parentheses.
*Statistically significant at the 10% level. **Statistically significant at the 5% level. ***Statistically significant at the 1% level.

Proceeding one step at a time, and replacing the original Berry et al. citizen liberalism metric with the newer Caughey-Warshaw citizenship liberalism metric (a composite of their "social" and "economic" liberalism measures), while leaving the original metric of government liberalism in place, produces the results seen in Table 2.5. The reconceptualized version of citizen liberalism is significant for Weak and Strong (but not Voluntary) policies, while government liberalism remains significant for Strong policies. Save for the time trend, no other variables emerge as significant.

Table 2.5. Data through 2009, Citizen Variable Updated, Multinomial Logit Model with Dependent Variable Reflecting Stringency (Omitted Category: "No RPS")

RPS Stringency	Voluntary	Weak	Strong
RE potential	$-3.29\text{x}10^{-9}$	$7.51\text{x}10^{-10}$	$1.58\text{x}10^{-9}$
	$(3.70\text{x}10^{-9})$	$(1.09\text{x}10^{-9})$	$(1.23\text{x}10^{-9})$
Percent contiguous states with RPS (lagged)	2.11	-0.426	0.763
	(1.50)	(1.27)	(1.30)
Citizen liberalism (Caughey-Warshaw average)	0.111	**0.173****	**0.180*****
	(0.0819)	(0.0699)	(0.0679)
Government liberalism	0.0284	-0.0143	**0.0794****
	(0.0346)	(0.0287)	(0.0366)
Percent Democratic in House	-3.75	2.47	2.68
	(3.52)	(2.61)	(2.78)
Electricity price	-0.0254	-0.171	-0.107
	(0.252)	(0.190)	(0.179)
Deregulated	-2.39	0.640	-0.0323
	(1.34)	(0.771)	(0.786)
Population growth rate	-15.18	15.63	6.30
	(34.85)	(28.97)	(33.82)
GSP per capita	3.49	41.03	14.90
	(51.99)	(47.85)	(52.66)
Year trend	**0.412****	**0.189***	**0.454*****
	(0.165)	(0.105)	(0.146)
Constant	-14.88	-17.12	-26.44
	(5.63)	(3.78)	(5.40)

Number of observations = 814. Standard errors in parentheses.
*Statistically significant at the 10% level. **Statistically significant at the 5% level. ***Statistically significant at the 1% level.

Reversing this approach symmetrically, and leaving the original citizen liberalism variable alone but replacing the government liberalism variable with the newer Caughey-Warshaw index, produces the results seen in Table 2.6. Citizen liberalism is (once again) significant for Voluntary and Weak policies, but not Strong, while government liberalism remains a significant indicator of Strong policies. The time trend fades from significance except for Strong policies.

Table 2.6. Data through 2009, Government Variable Updated, Multinomial Logit Model with Dependent Variable Reflecting Stringency (Omitted Category: "No RPS")

RPS Stringency	Voluntary	Weak	Strong
RE potential	$-1.399\text{x}10^{-9}$	$8.85\text{x}10^{-10}$	$4.80\text{x}10^{-10}$
	$(2.63\text{x}10^{-9})$	$(1.17\text{x}10^{-9})$	$(1.34\text{x}10^{-9})$
Percent contiguous states with RPS (lagged)	2.06	-0.570	-0.0989
	(1.80)	(1.30)	(1.29)
Citizen liberalism	**0.116*****	**0.0757****	0.0006
	(0.0405)	(0.0362)	(0.0343)
Government liberalism (Caughey-Warshaw index)	-0.0203	-0.0109	**0.0937*****
	(0.0397)	(0.0262)	(0.0349)
Percent Democratic in House	-4.19	0.295	2.57
	(3.30)	(2.44)	(2.99)
Electricity price	-0.0087	-0.085	-0.0034
	(0.231)	(0.171)	(0.152)
Deregulated	-1.66	1.04	0.460
	(1.28)	(0.714)	(0.687)
Population growth rate	25.35	26.86	11.17
	(51.25)	(29.18)	(39.24)
GSP per capita	50.19	59.14	-15.80
	(58.74)	(42.34)	(60.38)
Year trend	0.258	0.115	**0.590*****
	(0.188)	(0.106)	(0.197)
Constant	-13.36	-12.38	-18.52
	(4.10)	(2.46)	(3.91)

Number of observations = 814. Standard errors in parentheses.
*Statistically significant at the 10% level. **Statistically significant at the 5% level. ***Statistically significant at the 1% level.

Finally, analyzing the fully revised and updated model, with *both* original liberalism variables supplanted by the Caughey-Warshaw versions, produces the results seen in Table 2.7. Interestingly, citizen liberalism is (marginally) significant only for Weak policies, and government liberalism only for Strong policies. The time trend remains significant for all three.

**Table 2.7. Data through 2009, Both Political Variables Updated,
Multinomial Logit Model with Dependent Variable Reflecting Stringency
(Omitted Category: "No RPS")**

RPS Stringency	**Voluntary**	**Weak**	**Strong**
RE potential	$-3.93\text{x}10^{-9}$	$7.32\text{x}10^{-10}$	$1.13\text{x}10^{-9}$
	$(3.77\text{x}10^{-9})$	$(1.09\text{x}10^{-9})$	$(1.45\text{x}10^{-9})$
Percent contiguous states with RPS (lagged)	1.92	-0.499	0.0183
	(1.79)	(1.31)	(1.29)
Citizen liberalism (Caughey-Warshaw average)	0.0951	**0.175***	0.105
	(0.120)	(0.0912)	(0.0911)
Government liberalism (Caughey-Warshaw index)	-0.0134	-0.0031	**0.0658***
	(0.0453)	(0.0313)	(0.0383)
Percent Democratic in House	-2.88	2.12	3.03
	(3.47)	(2.45)	(2.85)
Electricity price	-0.0225	-0.146	-0.0950
	(0.260)	(0.182)	(0.178)
Deregulated	-2.43	0.630	0.1773
	(1.43)	(0.777)	(0.758)
Population growth rate	-19.08	15.57	13.90
	(35.50)	(29.82)	(38.16)
GSP per capita	11.25	38.82	-29.14
	(53.19)	(46.10)	(62.61)
Year trend	**0.403****	**0.193***	**0.595*****
	(0.174)	(0.107)	(0.183)
Constant	-13.65	-17.77	-22.03
	(5.88)	(4.20)	(5.14)

Number of observations = 814. Standard errors in parentheses.
*Statistically significant at the 10% level. **Statistically significant at the 5% level. ***Statistically significant at the 1% level.

2.6 Discussion

The purpose of this analysis is to evaluate which of a range of theoretically plausible factors influence subnational climate policy adoption, as exemplified by RPS policies, at different levels of policy stringency. In particular, it aims to refine and validate the findings from earlier research (Carley and Miller 2012) indicating that the only consistently significant factors are *political* ones—citizen liberalism in a more general sense (for policy adoption as a binary variable, and more specifically for weaker policy designs), and government liberalism in the context of stronger (more serious and ambitious) policy designs.

The possible underlying mechanisms linking these political variables to policy adoptions invite future research, but for the present it appears plausible, and consistent with other literature (e.g., Wiener and Koontz 2010), that policymakers' choices may be (at least partially) motivated by the extent to which such RPS designs can satisfy constituents' ideological preferences by functioning as symbolic politics. One might posit that even politically engaged citizens have limited interest in the details of policy design, or at least that policymakers perceive them accordingly. Thus a substantively weak policy is perhaps the best (least politically risky), or perhaps the only, available option under circumstances in which sufficient political conditions for *strong* policy adoption may not be present, despite apparently positive underlying fundamentals—for example, if wind or solar potential is plentiful but the governmental political context provides inadequate incentives to maximize its deployment.

It remains clear that the strongest RPS policies, relative to all states' policies, are not predicted by measurable indicators of citizen ideological liberalism, but instead by *government* ideological liberalism. This fits theoretical expectations—one might reasonably expect government ideology to have a more direct bearing on policy design (vs. broad policy choice) than citizen ideology, and one might also anticipate, all else equal, that policymakers with clear ideological commitments are more likely to be motivated to craft more ambitious policies.

Of course, the RPS is by no means the only policy instrument available to pursue energy or climate objectives, but its rapid spread provides critical insight into the circumstances under which states make policy decisions. For policymakers and advocates, it is valuable to know the circumstances most conducive to adoption of a particular kind of policy design. It also lays the foundation for more in-depth research. In the next section, I shift the focus to actual subnational policy actors, and use these findings as context for qualitative inquiry into their experiences and perceptions.

Section Two

2.7 Research Approach, Data, and Methodology

With the above as prologue, I move on to the qualitative portion of the state-level analysis. I use the findings about state-level political factors as the foundation for semi-structured interviews of a selective sample of state-level policy actors, seeking to provide experiential validation for the findings, as well as to lay the groundwork for inquiries concerning economic elite and interest-group sentiment in later parts of this dissertation.

The research in this section is empirical, and informed on a theoretical level by quantitative findings, but fundamentally qualitative in character. There are myriad distinctly qualitative approaches available to social science research (Corbin and Strauss 2007), but a recurring element among many is an emphasis on analysis as both an art and a science, carried out through a process of inductive reasoning. However, in the name of qualitative transparency (Jacobs et al. 2019), it is important for me to be clear about the details. As Gerring (2017) observes, there are few *purely* qualitative studies nowadays, as the inferential process is often informed by large-N studies (and indeed few purely quantitative ones as well, as interpreting data so often involves qualitative judgments).

Such is the case here. The overall process utilizes a sequential mixed-model strategy—what Lieberman (2005) calls a nested analysis—using large-N statistical analysis to guide more focused qualitative analysis of a small set of cases, which serves to gauge the plausibility of observed statistical relationships between variables. I have employed best practices for mixed-methods research as described in Teddlie and Tashakkori (2009) in regard to case selection and analysis, as detailed further below. In this instance I have drawn inferences from the earlier quantitative analysis to inform the development of the qualitative interview instrument, which generates both additional data, and interpretive context supporting further inductive inferences. The data-gathering and analysis are thus both exploratory and confirmatory, making use of comparisons and contrasts to interpret the results.

2.7.1 Selecting States and Finding Subjects

To generate those comparisons and contrasts, this research specifically targets a discrete pool of subjects in a small sample of states that stand out in the quantitative dataset as representative examples of different approaches to RPS policy (and by proxy, to broader climate policy initiatives), taking either leading or trailing roles in adopting policy innovations. The selection strategy is purposive (rather than probability-oriented), and in accord with the research goals is focused neither on "typical" cases nor extremes/outliers, but is instead the sort characterized as "maximum variation" (Teddlie and Tashakkori 2009) or "diverse" selection (Seawright and Gerring 2008; Gerring 2017), identifying a range of cases that represent full variation of the factors associated with the outcome(s) of interest.

Specifically, I identified six states on which to focus, respectively representing "early" and "late" adoption of RPS policies designated as "strong," "weak," and "voluntary." Thus the selection is informed by the dataset. With the focus on the year of initial policy adoption, which represents a state's only non-incremental policy action (Chandler 2009), the designation as early or late is relative to 2003, the median year in the dataset for RPS adoptions of all kinds. The designation as strong, weak, or voluntary depends on measurements of relative stringency, calculated as described earlier; the cutpoint between strong and weak policies for these cases is a stringency measure of approximately 70 (with slight variations over time), while voluntary policies are those including only aspirational goals, without any binding targets or enforcement mechanisms. Table 2.8 shows those selected for the qualitative component, arranged in a 2x3 grid according to these characteristics, while Table 2.9 summarizes the relevant data for all states in the dataset.

Table 2.8. States Selected as Targets for Qualitative Interviews

	RPS Stringency		
State Adoption Timing	*Strong*	*Weak*	*Voluntary*
Early	California, 2002	Wisconsin, 1999	Illinois, 2001
Late	New Hampshire, 2007	North Carolina, 2007	South Dakota, 2008

Table 2.9. States with RPS Policies, through 2009

State	Year RPS adopted	Initial RE Target (%)	Target Year	Starting mandate (%)	Initial load covered (%)	Voluntary	Stringency measure	Revision 1	Revision 1 Stringency	Revision 2	Revision 2 Stringency
IA*	1983	N/A	2000	0	75.7	N	N/A	1991	N/A	2003	N/A
MA	1997	4	2009	1	86	N	21.5	2008	70.79		70.79
NV	1997	3	2001	0	88.2	N	66.15	2001	49.61		49.61
TX	1998	6.4	2009	0	75.9	N	43.82	2005	44.83	2007	44.83
CT	**1998**	**27**	**2020**	**6**	**93.4**	**N**	**89.15**				**89.15**
ME	1999	30	2017	30	98.3	N	0.00	2006	49.15	2007	49.15
WI	1999	2.2	2012	0	100	N	16.92	2006	37.50		37.50
NJ	1999	6.5	2012	3.25	98.3	N	24.58	2004	35.50	2006	86.01
HI	2001	9.0	2010	0	0	*Y*	0.00	2004	52.63		52.63
IL	2001	15	2020	0	0	*Y*	0.00	2007	43.31		43.31
CA	**2002**	**20.0**	**2010**	**14**	**98.2**	**N**	**73.65**				**73.65**
NM	2004	10	2011	10	67.7	N	0.00	2007	41.68		41.68
MD	2004	7.5	2022	3.51	93.4	N	20.73	2007	31.11	2008	85.59
CO	2004	10	2020	3	58.7	N	25.68	2007	62.37		62.37
NY	2004	25	2013	20.2	84.7	N	45.17	2005	45.17		45.17
PA	**2004**	**18**	**2020**	**5.7**	**97.3**	**N**	**74.80**	**2007**	**70.40**	**2008**	**70.40**
RI	**2004**	**16**	**2019**	**3**	**99.3**	**N**	**86.06**				**86.06**
VT	2005	20	2015	0	0	*Y*	0.00				0.00
DE	2005	10	2019	2.01	56.5	N	32.24	2007	72.60		72.60
MT	2005	15	2015	5	66.6	N	66.60				66.60
SD	2006	10	2015	0	0	*Y*	0.00	2008	0.00		0.00
AZ	2006	15	2025	1.33	58.8	N	42.32				42.32
WA	**2006**	**15**	**2020**	**3**	**84.7**	**N**	**72.60**				**72.60**
VA	2007	N/A	2025	0	0	*Y*	N/A				
MO	2007	11	2020	0	0	*Y*	0.00	2008	65.00		65.00
ND	2007	10	2015	0	0	*Y*	0.00				0.00
NC	2007	12.5	2021	2.95	75.2	N	51.30				51.30
MN	2007	30	2020	15	47.8	N	55.15				55.15
OR	**2007**	**25**	**2025**	**5**	**74.6**	**N**	**82.89**				**82.89**
NH	**2007**	**23.8**	**2025**	**4.54**	**98.2**	**N**	**105.07**	**2008**	**105.07**		**105.07**
UT	2008	20	2015	0	0	*Y*	0.00				0.00
OH	2008	12.5	2024	0.25	88.6	N	67.83				67.83
MI	**2008**	**10**	**2015**	**4.8**	**100**	**N**	**74.29**				**74.29**
KS	**2009**	**20**	**2020**	**10**	**81.5**	**N**	**74.09**	2015	0.00		
WV	2009	25	2025	0	0	*Y*	0.00				

States are arranged chronologically by date of initial policy adoption. Bold indicated a policy with "strong" stringency at that time, a shaded background represents a policy with "weak" stringency, and the remaining policies are "voluntary" (nonbinding). *Iowa has a policy design that precludes a stringency calculation.

Using targeted keyword searches on DSIRE (NC Clean Energy Technology Center 2020) and other specialized publicly accessible databases, I first identified specific state-level policy initiatives in the selected states, related primary statutory and regulatory texts, and secondary literature on same. Most states had, and have, at least a few other energy and sustainability policies; e.g., net metering, interconnection standards, and solar/wind access rights. However, an RPS is typically one of the more comprehensive and broad-based policies of this type in most states. The policy history for the selected states is summarized below.

In 1999, Wisconsin added to its then-portfolio of two other statewide renewable energy (RE) regulatory policies (plus two local ordinances in Madison) by passing a statewide RPS, becoming the first state to do so without restructuring its electrical utility industry in the process. It set a standard requiring that 2.2 percent of all electricity consumed in the state be generated from renewable sources by December 31, 2012. This was not an especially stringent policy at the time, and although it was later amended in 2006 to require 10 percent RE by December 31, 2015 and thereafter, it remains weak compared to other states.

In 2001, Illinois added to its slate of two other statewide RE policies (and one in Chicago) by passing HR 428, creating a special subcommittee on RE development, specifically dedicated to crafting and enacting a statewide RPS. While this bill introduced the concept into state law and established the goal, however, Illinois did not enact binding and enforceable RPS standards until 2007. It later updated those standards in 2016.

In 2002, California added to its slate of six statewide (and two local) RE regulations by passing an RPS requiring 20 percent of state electricity to come from RE sources by 2010. This was a strong and ambitious policy at the time, and it has since been integrated into the state's broader-based Global Warming Solutions Act (HB-32 2006), and its RE targets have been updated more than once—currently requiring 60 percent by 2030, with substantial interim targets along the way.

By 2007, RPS policies had long since become a trend, enacted by many other states. In that year North Carolina joined the list and added to its four statewide (and three local) RE policies then extant with a statewide RPS, but a relatively weak one, mandating investor-owned utilities provide 12.5 percent of electricity from RE sources by 2021. Municipal and cooperative utilities have a slightly different set of rules, requiring 10 percent RE by 2018 (and thereafter).

Also in 2007, New Hampshire built on a slate of seven other statewide RE policies by requiring utility providers (excepting those municipally owned) to meet the ambitious goal of 23.8 percent of electricity from RE sources (or to procure equivalent Renewable Energy Certificates (RECs)) by 2025. The following year the state legislature amended that to be even more stringent, updating the target to 25.2 percent.

In 2008, South Dakota doubled its slate of statewide RE policies (the other being an energy-related residential building code, also voluntary) with the bipartisan passage of a nonbinding RE "objective" setting the goal of deriving 10 percent of all retail electricity sales in the state from RE sources by 2015. Electrical providers were required to provide a brief annual report to the state Public Utilities Commission about any steps taken toward the goal, but not required to take any. (The following year the legislature accomplished the distinctive feat of weakening an already completely voluntary policy by allowing "conserved energy" to be counted toward the goal.)

From this point, I grounded the research project in best practices for recruiting and interviewing political elites, as established in the literature (Peabody et al. 1990). Using these six states' respective publicly accessible legislative websites, I began by identifying the legislators who originally drafted, sponsored, or co-sponsored each of the bills under discussion. I then conducted searches for the present status and contact information of those individuals, starting with those governmental resources, and also utilizing corporate and nonprofit databases, social media sites such as LinkedIn and Facebook, assorted people-finder databases, and other *ad hoc* search techniques. Some of these individuals are deceased or incommunicado, but it was possible to locate many, and to track down others—as well as to identify and locate additional prospects—through referrals provided by the initial contacts, in the fashion of an expanding "snowball sample." Beyond state legislative policymakers, this sampling technique led the overall sample set also to include individuals from state agencies, nonprofit organizations, and even intergovernmental agencies (specifically the Western Climate Initiative).

The overall subject list ultimately included 72 individuals, reflecting multiple ages, races, genders, party affiliations, and backgrounds in and out of government. Of these, I was able to identify contact information for and reach out to 54 (using contact and recruiting language approved by IU's Institutional Review Board (IRB)), through initial inquiries and up to two rounds of follow-up contacts. Of these, 16 replied to the inquiry, and nine ultimately participated in the requested interviews. Fortuitously, these nine spanned the broadest possible range of states, policy types, genders, ages, political parties, and current political status (i.e., both in and out of public office). To encourage candor, all participants were offered anonymity, although some voluntarily consented to allowing their responses to be quoted and/or identified. Naturally, any particular interview subject may not necessarily agree with the findings of this research.

2.7.2 Interviews and Coding

The most suitable data-gathering approach for a project of this sort goes by various names in the literature on qualitative methods; Teddlie and Tashakkori 2009 refer to it as the "standardized open-ended interview," but most often, as in Adams (2015), it is known as the *semi-structured interview*. Adams describes it succinctly as positioned between "standardized, mostly closed-ended surveys of individuals and free-form, open-ended sessions with [focus] groups" (Adams 2015, 492).

Following qualitative best practices (Peabody et al. 1990; Corbin and Strauss 2007; Teddlie and Tashakkori 2009; Blandford 2013; Adams 2015) for a project with these characteristics, I developed the content of the basic interview prompts based on the findings described above and the secondary literature. The prompts are designed to elicit subjects' personal experience, impressions, and perspectives about the factors driving RPS and similar energy and climate policy adoption (and opposition), including public attitudes, elite attitudes, lobbying influence, and the overall political context impacting past, present, and possible future policy enactments, without imposing pressure to give any particular "socially acceptable" answers. The interview prompt template, as approved by IU's IRB, is included in the Appendix.

The interviews did not involve live fieldwork: they were conducted primarily by phone (and/or email, depending on a respondent's preferences), with follow-up exchanges as necessary to clarify or expand responses. The modal initial phone interview lasted approximately 20-30 minutes, while the longest lasted well over an hour. All phone interviews were recorded and transcribed. Rounds of contacts and interviews continued until reaching a point of diminishing returns of new information, *aka* the point of "theoretical saturation… (within the limits of available time and money)" (Corbin and Strauss 2007), at which no new contacts or data were emerging that would add (respectively) to the network and the patterns already discerned.

Simultaneous with the process of gathering the interview data, I compiled and coded it using an open-source CAQDAS (computer-assisted qualitative data analysis software) package called Dedoose. I conducted the coding and analysis pursuant to best practices as described by Saldaña (2013), emphasizing "descriptive" coding (to assign categorical labels), "hypothesis" coding (to assess expectations from the statistical analysis), and "pattern" coding (to identify recurring sets, themes, and attributes). From the cumulative responses gathered, I was thereby able to extract thick descriptive observations of the state-level climate policymaking process: descriptions not just of events but their context, including the patterns of cultural and social relationships involved, as subjectively understood by those engaged in the events. From these descriptions, it is possible to derive lessons that can be applied to future policy initiatives.

2.8 Analysis

Stated succinctly, the goal of this section of the study is to provide experiential evidence regarding the factors previously found to contribute to subnational adoption of climate-related policies (specifically RPS policies), grounded in subjective thick description of the experience of crafting, enacting, and/or overseeing those policies. My initial expectation was that the results would validate or at least complement the findings of the statistical analysis, identifying political factors as dominant—specifically, government liberalism for more stringent policies, and citizen liberalism for weaker policies, with stronger indications of symbolic politics driving voluntary policies.

2.8.1 Results

Certain themes recur with only minor variation across multiple responses. State officials and stakeholders commonly report that the general public was broadly indifferent to the details of climate policies in general and RPS policies in particular, although broadly supportive of initiatives perceived as "environmental." Respondents did not recall significant levels of advocacy, of any kind, from grass-roots constituents. As one respondent puts it, "the public shows up at the ballot box every so often, but when you're doing program design and implementation, what you're really dealing with are interest groups." Policy details are described (for the public, and in some cases officials as well) as "pretty abstract," "very complicated," and "hard for people to understand." Respondents characterize this as an obstacle to substantively ambitious policy. (It is important to note a potential limitation here, as evidence suggests that politicians of both parties consistently misperceive grass-roots constituents' preferences, subjectively underestimating their interest in change and overestimating their desire for conservative policy stances (Broockman and Skovron 2017)). Nonetheless, as one individual from a “voluntary” RPS state noted, “officials want to be on the record for supporting something, rather than just opposition.”

At all levels of policy, most respondents describe proposals on these issues facing a significant partisan divide. In one voluntary-RPS state, “the Republicans dominated it, and preferred to have a goal rather than a standard… Republicans by and large oppose *any* regulation, including a mandatory standard.” In a strong-RPS state, “even back in pre-tea party days, there was a reluctance among Republicans to support anything that spoke about the need to mitigate climate change,” and both “Republicans and moderate Democrats were pretty hostile.” In sum, proactive policy support from Democrats and, where substantively ambitious policies were concerned, specifically from *progressive* Democrats, was a *sine qua non* for policy enactment. In a state that passed a weak policy, this divide was still present, but with “moderates” aligned differently: a respondent described the policy being enacted because “you had this moment of Democratic control and a progressive Speaker and unique situation [with sponsorship from] a moderate, old-school Democrat who was willing to push the limits on certain issues.” Multiple respondents described the political environments in their states as growing only more polarized in the years since these policies were initially adopted, and especially since 2010. Multistate compacts like the Western Climate Initiative fell short of their original ambitions for similar reasons, as control of state legislatures and/or governorships shifted to more conservative hands and states withdrew from participation.

Most of the lobbying on RPS and related proposals came from energy producers and utilities, and more broadly “big business” (e.g., the Chamber of Commerce), with comparatively less involvement from familiar high-profile public interest groups (e.g., the Sierra Club) and extremely little from grass-roots organizations that are oftentimes (in the eyes of respondents) loosely organized. In contrast, the concerns of industry stakeholders were numerous and well-represented by lobbyists because “they had the most at stake”; reforming the energy sector “was a little bit like fixing a flat tire without stopping the car... The idea was, the paramount goal, was get a clean uninterruptible supply of electricity. If you’re doing that, we’ll cut you some slack.”

Opposition was ideological as well as economic; multiple respondents describe a partisan divide even among business interests. Broadly speaking, however, industry was wary of new regulations primarily because of economic uncertainty involving future costs: in the words of one respondent, what business wants from government is “two things: predictability and deductibility. So they’re interested in: is this going to cost me any more?” Among industry’s primary goals, mentioned several times, “was to produce energy inexpensively.”

However, both industry and Republicans were more receptive (along lines similar to those discussed in Wiener and Koontz 2010), or at least open to negotiation, when an environmental proposal could be framed as an economic development opportunity, offering new revenue. Lobbyists and even CEOs are described as having been willing to “play ball” and negotiate terms, and some Republicans were willing to offer bills bipartisan support, when they were positioned as involving “smart growth,” or “‘double bottom line issues’ [involving both] economic development [and] environmental sustainability,” in the words of one respondent from a weak-RPS state.

2.9 Discussion

On the whole, these qualitative findings complement the quantitative findings. There are three core propositions involved here:

1) Specific energy- and climate-related policies, and the design details thereof, appear to be relatively low-salience for the general public, although voters evince soft support for "environmental" issues as a category, in ways that enable lawmakers to satisfy them with any indication that they're taking action, even if it is symbolic and/or substantively meaningless.

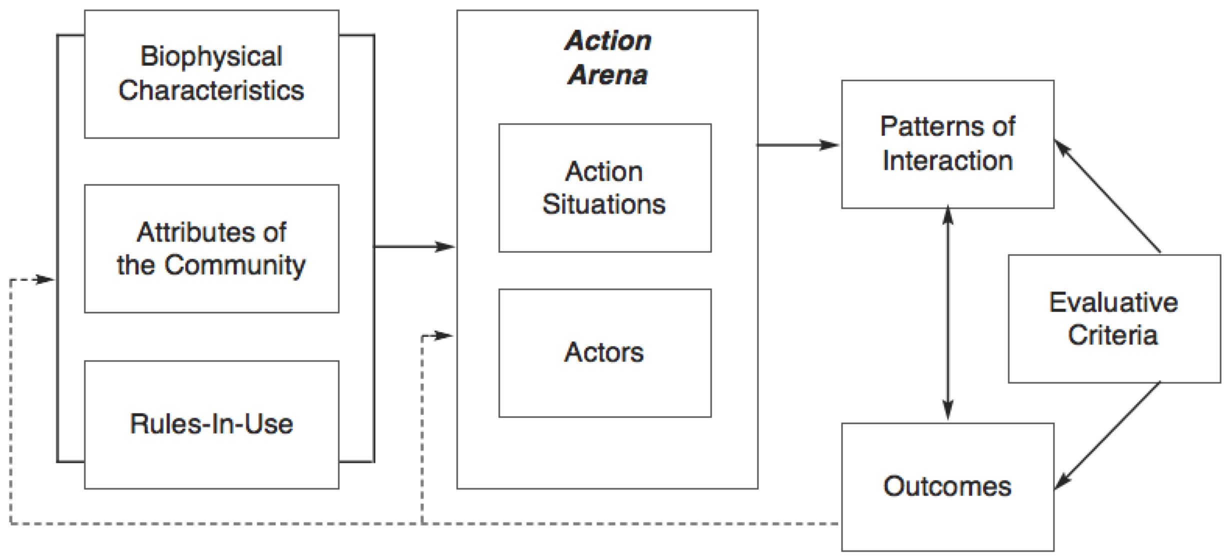
2) Substantive but weak policies in a state arise when policy proposals reflect broad-based citizen liberalism in ways that can bridge partisan divides (e.g., balancing environmental with economic goals), bringing "moderates" aboard and placating industry interests.

3) Stronger substantive policies in a state result when the government itself is more ideologically liberal, able to muster both the issue-level commitment and the political wherewithal to pass a bill notwithstanding opposition from conservatives and/or industry.

While the behavior of any given set of policy actors is always multifaceted, the semi-structured interviews described above provide direct, policy-level support for these propositions drawn from the experiences and perspectives of multiple state-level participants in the policymaking process.

Amongst the many extant theoretical approaches to that policymaking process, it may be helpful to frame these findings and patterns within the terminology of the Institutional Analysis and Development (IAD) framework and the Social-Ecological System (SES) framework, developed by Elinor Ostrom (Ostrom 2011; Ostrom, Cox, and Schlager 2014). Both frameworks are designed to illuminate the characteristics of institutional dynamics without requiring precisely specified models or variables. The SES framework was originally conceived as a means to focus specifically on systems of common-pool (ecological) resources in which participants extract and use those resources, but over time the SES framework has been expanded to encompass applications of broader scope (Ostrom, Cox, and Schlager 2014; McGinnis and Ostrom 2014), and recently the two have been integrated into the Combined IAD-SES (CIS) framework (Cole, Epstein, and McGinnis 2019). The traditional IAD framework is depicted in Figure 2.1.

Figure 2.1. The Ostrom Institutional Analysis and Development Framework



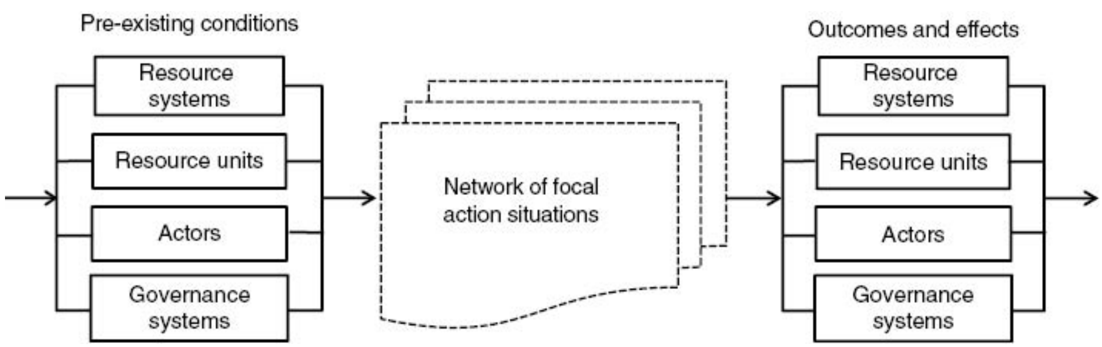
From Ostrom, Cox, and Schlager (2014): 271

This approach situates the interview data gathered herein as descriptions of actors, rules-in-use, and other variables operating at multiple levels in "action situations." The action situation is the heart of the IAD framework. Within action situations, actors may be serving their own interests or operating as agents on behalf of other actors (individuals or organizations); in either case their behavior is presumed to be boundedly rational. In the cases under examination here, among the three categories of "contextual factors" feeding into the action arena, biophysical conditions can be regarded as relatively unimportant (however much it might seem sensible for them to inform decisions about energy systems and sustainability), while attributes of the political community (notably levels of mutual trust and shared habits of reciprocity, especially where party identity is concerned) and rules-in-use (including norms and understandings, as opposed to formally promulgated rules of conduct) stand out as crucial. In the context of these factors, individuals enter into action situations in positions/roles (e.g., legislator, bureaucrat, lobbyist) that invest them with certain powers, but also constrain their behavior and interactions. These actors make decisions in light of information about the likely actions of other participants and the perceived benefits and costs involved, and these decisions aggregate in patterns of interaction that produced observable outcomes. They are structured by various kinds of rules-in-use that govern matters such as the methods of aggregation, potential payoffs, and scope of the decisions. The decisions being made are at the operational and collective-choice (i.e., policy) levels, but not the constitutional level; the actors involved do not have the authority to change top-level rules regarding who is empowered to participate in these decisions.

The actors engaged in these decision processes are not only elected policymakers, but also lobbyists and industry experts who negotiate the terms of legislation with them. The legislators have formal decision authority, but it is constrained by the inputs of the other actors. All of these actors contribute information and expertise, and assign perceived costs and benefits to different courses of action. All of these actors are also informed by contextual factors, including not only social and economic phenomena but also relationships with individuals and entities who are not direct participants (e.g., the general public, voters, outside interest groups, and the corporations and industry associations for whom lobbyists serve as agents).

Moreover, the outcomes of these decisions are subjected to evaluative criteria, which (like the contextual factors) implicitly emerge from other action situations. These factors and criteria are not necessarily unique, but often apply within a network of related action situations; indeed, evaluation can be seen as an action situation in its own right. The outcomes thereby "shape their own future operation as well as the concurrent (and subsequent) operations of other action situations to which [they are] connected" (Cole, Epstein, and McGinnis 2019, 255). This is reflected in the CIS framework diagram, as depicted in Figure 2.2.

Figure 2.2. The Combined IAD-SES Framework



From Cole, McGinnis, and Epstein (2019): 255

In this analysis, the expanded CIS framework can be particularly useful for delineating in greater detail several second-tier attributes that limn the boundaries of the action situations under examination. As fully elaborated, it includes several subsystems of attributes derived from the SES framework (Cole, Epstein, and McGinnis 2019). In particular, first amongst these in relevance would be several key attributes of the actors involved, notably:

- Their number (large, with the size of the state legislature being the logical minimum and expanding from there)
- Their socioeconomic attributes (with the most active participants possessing higher-than-average socioeconomic status)
- Their history and past experiences (with previous similar proposals and the economic and political consequences thereof)

- Their locations (in states with particular political characteristics; other distinguishing ecological and economic attributes are theoretically relevant but do not arise frequently in the interview data, just as they do not in the statistical analysis)
- Their leadership status (in either political or economic terms), and especially…
- The norms of trust and reciprocity that constrain their actions (and which are regularly described as low and falling due to partisan polarization).

Second, the more granular list of attributes would also include the activities and processes intrinsic to the action situations, including information sharing, deliberation, conflict resolution, investment opportunities, lobbying, networking, and other forms of *ad hoc* organizing. (In this regard, again in light of polarization, dynamics *within* a party identity shared by key actors emerge as more important than dynamics *between* parties, inasmuch as the latter are so often conflictual and, if not so, can be counterproductive in that bipartisan cooperation actually operates to impede politically feasible policy action.)

Third, it would include evaluative criteria applicable to outcomes, especially "social performance measures" such as economic efficiency and political accountability (and, of lesser importance, equity and sustainability). In light of its recurrence in both the literature and these qualitative findings, it seems fair to say that if an "economic development" frame can be applied in advance to potential outcomes, it makes a crucial difference to the political feasibility of policy actions under consideration.

All of these (and other) factors included in the CIS framework are by their nature dynamic, situated in systems which may be evolving or iterative, but they are most easily interpreted as parameters in place at a given point in time. This is certainly the case for the cases examined here, which (within each state) took place over relatively compact timeframes.

This is of necessity a brief examination of the CIS framework as applied to this research, not an in-depth application of Ostrom's principles. Nonetheless, it does help to structure the observations and the hypotheses they support. In other words, it appears clear that the rules, norms, roles, and relationships that primarily shape state-level decision processes and outcomes regarding the RPS and related energy and climate policies are, first and foremost, partisan (in terms of both ideology and oppositional power dynamics); secondarily, economic (in terms of both opportunity and predictability); and in tertiary position at best either ecological (in terms of policy effectiveness and other technical details) and/or democratic (in terms of being driven by the public will).

The qualitative data-gathering and analysis process described above is, in a sense, a matter of working backward through the IAD flow diagram. The outcomes are known. The patterns of interaction that led to them, and the external factors that informed those patterns, are less visible, but are revealed through the experiences and perspectives described by the participants. These perspectives inform our understanding of future possibilities, as participants in similar roles will be making energy and climate policy decisions going forward, in settings involving similar roles, relationships, rules, constraints, and criteria.

Hence, although this part of the dissertation has a somewhat loose connection to the whole insofar as it does not directly address geoengineering policy proposals, it lays critical groundwork and contributes important context to the search for *politically viable* avenues to climate policy formation. It provides experiential confirmation of the findings from the quantitative analysis components (both retrospective, in Section One of this chapter, and prospective, to come in Chapter Three), and establishes key parameters for the Qualitative Comparative Analysis in Chapter Four, while contributing to the theoretical constructs that underlie both those analyses. It also serves to unearth and clarify meaningful differences between how the political viability of policy options is conceived by practitioners, versus how it can be perceived by scholars. If the characteristics that made the RPS politically viable and, indeed, popular were almost entirely matters of partisan political ideology, what lessons can we draw from that about how to address the political impasse over climate change more broadly, and about the political prospects for geoengineering more specifically?

2.10 Appendix

2.6.A1 Semi-structured Interview Template

In your role as [role] of [organization], you were involved in [implementation or passage of selected state policy]. The following questions ask to recall your personal experiences in that role. There are no right or wrong answers; please feel free to share your thoughts, whatever they may be.

1) How would you describe the nature of your role in relation to [policy]? How did you come to be in that role?

2) What was your impression of public attitudes in relation to [policy]? Did they differ by political party or some other noticeable characteristic?

3) What was your impression of the attitudes of other public officials in relation to [policy]? Did they differ by political party or some other noticeable characteristic?

4) What was your impression of the attitudes of economic elites (such as industry executives or investors) in relation to [policy]? Did they differ based on economic or political interests in the policy?

5) What kinds of lobbying efforts did you encounter in relation to [policy]? Did they come primarily from economic interest groups or grass-roots groups?

6) What barriers (either political or economic) did you encounter to [policy], and how have you seen those barriers change over time?

7) What other noteworthy factors do you recall influencing the [adoption/implementation of policy] in [state]?

8) Are there any other relevant individuals you would suggest we contact about [policy]?

3 Seeing the Climate from Above: Representational Inequality and Economic Elite Attitudes

3.1 Background

Climate change poses a complex threat to human civilization on a global scale, but there are equally complex barriers to implementing policies to address it. In the United States today, the political environment poses serious obstacles to legislating policy responses to a long list of salient policy problems, climate change prominent among them. Strong partisan polarization and increased economic inequality both exacerbate the difficulties already inherent in climate policy formation, in a dynamic that now extends over many years (Sunstein 2007). As a consequence, political resistance to climate policy action has been consistently high, and remains so today, for multifarious reasons (social, economic, and ideological) unrelated to the substantive merits of actual or potential policy proposals.

Scholars and policy entrepreneurs have advanced numerous ideas for policy instruments to address the climate threat—from taxing carbon emissions (Nordhaus 1992; 2007) to wide-ranging portfolios of "stabilization wedges" (Pacala and Socolow 2004; Nauclér and Enkvist 2009) to cooperative international "climate clubs" (Nordhaus 2015; Cramton et al. 2017). Some efforts at cooperation have demonstrated the potential to inform policymaking at least briefly—such as the U.S.-China Climate Change Working Group (CCWG), established in 2013 (Jiahan 2018), with a set of nine cooperative "action initiatives," or the California-Quebec-Nova Scotia partnership that carries on the mandate of the Western Climate Initiative (WCI), founded in 2007, which aims to maintain a carbon trading market. Most actual policy initiatives thus far remain on the drawing board, however, having failed to surmount the political resistance, as with multiple attempts at carbon pricing (Rabe 2018; Jenkins 2019)—and indeed the abovementioned examples also illustrate this, as the CCWG has faltered since the 2016 U.S. election (Jiahan 2018), while today's WCI is just a vestige of a coalition that once contained seven U.S. states and four Canadian provinces, and is currently battling lawsuits brought by the Trump administration (White and Blatchford 2019). Political resistance can be a significant cost factor in assessing policy costs and benefits (Richards 2000; Krutilla 2011), yet it is too often neglected by analysts. Most scholarship on climate policy focuses strongly on traditional metrics of policy analysis—notably, the economic efficiency and/or scientific effectiveness of any given policy instrument or combination of instruments. Meanwhile, political viability—the prospect of a policy proposal actually being enacted and implemented by those who influence and direct the policymaking agenda—is all too often mentioned only in passing (Fullerton 2001) or not at all.

A few climate policy options—in particular, those often grouped together under the rubric of "geoengineering"—have been observed to elicit less political resistance from the general public than others (Mercer, Keith, and Sharp 2011; Pidgeon et al. 2012; Kahan et al. 2015). However, public opinion alone is neither necessary nor sufficient for policy formation (Gilens and Page 2014): increasing economic inequality has driven representational inequality as well, with the result that general public preferences are routinely superseded in the policymaking process by the preferences of economic elites. As the findings of Chapter Two demonstrate, elites themselves are not immune to political division, and many demonstrate political resistance to climate action, contributing to the ongoing policy stalemate. It might be possible, however, that like the general public they demonstrate comparably increased openness where geoengineering is concerned.

Hence, this chapter of this dissertation analyzes the effects of economic status as a filter for the political viability of climate policy options in general, and geoengineering in particular, to assess whether it might provide a vehicle for politically viable policy implementation. It focuses on investigating the attitudes of individual economic elites, attitudes which have been shown in many cases to dominate the political behavior of policymakers. The approach is quantitative, gathering data through a survey experiment and utilizing both parametric and non-parametric modes of analysis to determine elites' degree of openness to climate policy interventions, in a traditional regulatory context as compared with a geoengineering context.

This study makes several meaningful contributions to existing literature. First, it refines and attempts to replicate previous research on public attitudes toward geoengineering. Second, it adds to that research by adopting an approach focused on economic-elite opinion, as an indicator of political viability. In doing so, it unites three strands of literature—one focused on analyzing policy instruments, in which political factors are largely neglected; one focused on how polarization and inequality impact quality of representation, in which policy options matter only as examples; and one focused on modes of communication about policy risks and scientific information—and opens up new avenues for interdisciplinary dialogue and future research.

3.2 Research Question

Studies indicate that median public attitudes reflect greater openness to geoengineering-related initiatives, relative to other climate policy options. Does this openness extend to those subsets of the public whose views exert disproportionate influence over political viability? Specifically: do the individual attitudes of economic elites reflect comparable openness?

3.3 Review of Relevant Literature

Across a wide range of studies, much of the scholarly analysis of climate policy in general, and of geoengineering in particular, focuses on conventional criteria: effectiveness, economic efficiency, technical feasibility, ecological risk. A few climate policy scholars in recent years have focused attention on some aspects of policy instrument choice that go beyond these conventional criteria; such work often points to the psychological and attitudinal factors involved. For instance, exploring the "stabilization wedge" concept (Pacala and Socolow 2004; Nauclér and Enkvist 2009), Carrico et al. (2011) focus on the "wedge" of individual and household behavior, zeroing in on the demand side of the energy sector rather than the supply side. They note that conventional economic incentives can actually be counter-productive when attempting to modify behaviors otherwise driven by intrinsic norms, and that individual behavioral choices are not necessarily grounded in stable preferences but often depend upon the framing of information related to the issue.

Except in passing, however, climate policy scholars have not taken up political viability as a criterion.

Tangentially relevant information has been uncovered in the context of studies on political communication and opinion formation. For instance, studies of public opinion on carbon capture and storage (CCS) technology exemplify the disconnect between scientific understanding and public views on policy instruments. (Note that CCS is sometimes discussed in the same context as geoengineering, especially when it involves innovative ways to repurpose carbon and create marketable products from it, as discussed in Chapter Four. However, such efforts are a small portion of the overall CCS domain, which is usually perceived as involving complicated and expensive long-term storage challenges.) Analyzing a survey in Indiana concerning CCS, Carley et al. (2012) find that the majority of respondents hold no strong opinions on the matter, but among those who do, those opinions are best predicted by *ex ante* political and ideological views. This pattern pertains even outside the U.S.: in an international study conducted in Australia, the Netherlands, and Japan, Dowd et al. (2014) find poor public understanding of the scientific characteristics of carbon dioxide, yet find that improvements in this knowledge only indirectly relate to opinions of CCS implementation. In an overview of studies of public perceptions of CCS, L'Orange Seigo, Dohle, and Siegrist (2014) likewise find the relationship between knowledge and acceptance to be moderate, at best.

However, geoengineering approaches seem to pose a contrast to this dynamic. Although they span a wide variety of scientific disciplines and potential economic tradeoffs, what they have in common is that when exposed to public opinion, they do not elicit reflexive skepticism on ideological grounds to the same degree as conventional policy instruments. Instead they garner at least provisional support, apparently grounded in a broad public sense of technological optimism. This is explicitly clear in the work of Kahan and colleagues in the Cultural Cognition Project (CCP) at Yale (Kahan et al. 2015), and other literature suggests comparable findings.

One possible reason may be that low public salience has made geoengineering less susceptible to leverage as a wedge issue by partisan activists, avoiding the kind of cues that drive "conflict extension" and exacerbate polarization (Layman, Carsey, and Horowitz 2006; Layman et al. 2010). At one time attitudes on racial issues and, to some extent, cultural issues, were orthogonal to the conventional political spectrum, but in recent decades those counterweights have realigned to be congruent with other political attitudes, and party positions have realigned in conjunction with them... with the result that political influencers find it increasingly easy to leverage essentially any issue both to mobilize supporters and to vilify opponents, with little fear of cross-cutting loyalties (especially among self-identified conservatives).

However, not all issues are deemed advantageous for strategic deployment at the same time, nor could they be; conflict extension is largely opportunistic. Reviewing existing studies in the climate policy domain, Corner, Pidgeon, and Parkhill (2012) and Scheer and Renn (2014) both find general public knowledge about geoengineering to be low, but attitudes (when prompted with information) to be open-minded and cautiously supportive (albeit varying depending on cultural views, as Kahan and his colleagues also found). This openness manifests somewhat more for carbon dioxide removal (CDR) approaches as compared to solar radiation management (SRM), and likewise more so for additional research and development (R&D) than for immediate deployment—not unlike the attitudes of scientists studying the field. Cusack et al. (2014) attempt to expand the range of analysis by considering institutional capacity and (like a handful of others) public acceptance as well as conventional scientific criteria.

Mahajan, Tingley, and Wagner (2018) administered questions specifically about SRM to a 1000-subject subset of the 2016 Cooperative Congressional Election Study (CCES), a large-N national survey. They found generally low levels of public awareness, but to the extent people perceived it to be fast and inexpensive, they were more supportive of its use. Party affiliation was also significant, as Republicans were both less supportive overall, and less concerned about both SRM's risks and its benefits.

Outside the American context, Pidgeon et al. (2012) assess public opinion in the UK, characterizing geoengineering as a term around which entrenched attitudes and social representations have yet to be established, and finding that brief explanations to improve baseline awareness produce positive responses. The Integrated Assessment of Geoengineering Proposals

(IAGP), carried out by a coalition of six UK universities, conducted four focus groups across the UK in 2012, finding that attitudes vary widely, although they appear to coalesce around the notion that geoengineering would not be beneficial on its own, only if accompanied by mitigation, and that research should be conducted safely and transparently (Vaughan 2014). Beyond the UK, the European Trans-disciplinary Assessment of Climate Engineering (EuTRACE) offers a larger-scale multi-year, multi-country qualitative assessment of public knowledge and attitudes about geoengineering. Conducted by a consortium of 14 organizations from five western European countries, EuTRACE engaged in public information campaigns, and conducted events with assorted experts, stakeholders, and the general public in six major cities in 2012-2014. The findings vary across countries, but common threads include the proposition that geoengineering techniques would benefit from being disaggregated and discussed (and researched and regulated) separately, while at the same time geoengineering needs to be integrated more comprehensively into broader discussions of climate change. Attitudes in the EU were found to vary from those in the U.S. (and Russia), where "some actors are asking why should field research and deployment not be attempted immediately, before governance mechanisms are in place" (Adriázola et al. 2015, 10). The prospect of actual governance, meanwhile, was found to be remote, in the absence of any obvious institutional arrangement with the authority to impose it.

Not everyone agrees that the less-polarized state of public opinion on geoengineering positions it as a promising category of policy instruments. Verchick (2016), for instance, springboarding from the same work by Kahan and the CCP (Kahan et al. 2015), nonetheless prefers to focus on public perceptions of adaptation-related policy instruments, deeming geoengineering "too uncertain" and "not yet… the object of serious policy proposals" (Verchick

2016, 972). As the example of cap-and-trade systems' shifting political acceptance from the 1980s into the 2010s demonstrates, however, politicization of policy ideas is a process that takes many years; it does not happen overnight. It may be the very dearth of policy attention to date that marks geoengineering as potentially more politically viable than more familiar alternatives, and presents a window of opportunity. The goal of the study described in this chapter is to test that political viability—not in terms of general public attitudes, but instead as filtered through the "economic elite domination" framework presented by Gilens and Page (2014).

3.4 Research Approach, Data, and Methodology

To discern the influence of individual economic status on climate-specific policy attitudes, I conducted a survey experiment closely modeled on the methodology of Kahan et al. (2015). The goal is to determine whether making geoengineering more salient as a potential policy solution to the risks associated with climate change will reduce political resistance compared to other climate policy options.

Kahan and his colleagues focus on the psychological and cultural underpinnings of risk perceptions regarding climate change, exploring how those perceptions are modified by information about geoengineering and relating those results to a "cultural cognition thesis" (CCT). However, in doing so they utilize a sample chosen to be demographically comparable to the adult population, subdivided not by economic status or other typical control variables, but by "worldviews" measured along two separate dimensions (individualism and egalitarianism), designed to test a "cultural evaluator model" of political communication. These "worldview" dimensions *per se* are not relevant to the present inquiry, so I chose to disregard them (while noting that both worldviews are orthogonal to most other demographic factors, and hence both contribute to aggregate public opinion). I instead screened an otherwise random sample of adult Americans by household income, to identify respondents who qualify as affluent "economic elites" according to the criteria employed by Gilens (Gilens 2012; Gilens and Page 2014): specifically, those at or above the 90th percentile of income.

The fact that affluent Americans are traditionally underrepresented in survey respondent pools may impose some limitation on the generalizability of the results. This is the reason for filtering respondents at the 90th income percentile rather than some higher threshold, although individuals above that level—approximately $175,000 in 2018 dollars—are not necessarily among the richest or most elite. Gilens and Page (2014) confront this same dilemma, however, and observe that the 2011 CCES finds that the policy preferences of the *very* wealthy, the top 2 percent of earners, correlate far more strongly with the top 10 percent (r=.91) than with the median respondent (r=.69). Accordingly, the views of the top 10 percent present an effective proxy for the views of those even richer. Gilens and Page's findings indicate that using this cutpoint does establish a clear and significant distinction from median public opinion. (It may be arguable that the very uppermost slice of the distribution, the top 0.1 percent, exercises more *direct* influence over policy, but data gathering about public opinion within that demographic slice is notoriously problematic. Almost all research along these lines is limited by the need to use imperfect proxies for the attitudes of the extremely wealthy.)

3.4.1 Survey

I administered the survey via the SurveyMonkey for Academics online survey platform (www.surveymonkey.com), using its Audience respondent pool to target a sample representative of the adult U.S. population. SurveyMonkey Audience is a proprietary pool drawing its panels from over 2.5 million respondents, recruited using a voluntary "charitable incentive" model to deter self-interested participation. It conducts regular fraud prevention and calibration testing (SurveyMonkey 2020), and limits participation frequency to ensure high engagement and data quality. Panels utilize Census-based age and gender balancing to ensure representative samples, and allow prescreening of respondents on a wide variety of demographic criteria, including household income. Participants in this study were screened for incomes above $175,000 per year. The survey was conducted in July 2019, and ultimately gathered 605 total responses. After data cleaning, this was reduced to 568 responses. Randomly divided between two treatment groups, this was sufficient to allow for a 95% confidence level with a 6% margin of error. (A statistically larger sample was not feasible due to the limited number of income-qualified participants available in the respondent pool.)

Subjects were randomly assigned to two groups, and each was instructed to read a brief (composite) news report, as an experimental treatment. Group A read a report describing how members of a scientists' professional association (the "American Academy of Geophysical Scientists," AAGS) have called for adoption of a regulatory cap on CO_2 emissions even lower than the consensus 450 ppm target approved by the United Nations Framework Convention on Climate Change (UNFCCC). Group B read a similarly structured report introducing basic concepts of geoengineering, and describing how members of the AAGS have called for greater public investments in geoengineering as an alternative to stricter CO_2 emission limits. All subjects were then instructed to read a second vignette, an excerpt from a (composite) scientific article in the journal *Nature Science* reporting evidence that past estimates of atmospheric CO_2 concentrations had been overly optimistic; that emissions limits designed to cap those concentrations at 450-600 ppm would likely be insufficient to avert a range of catastrophic climate effects, ranging from drastically rising sea levels to famine-inducing droughts; and that indeed some irreversible effects have already taken place, even if we were able to halt carbon emissions today. (See Appendix for treatment articles).

Subjects were then asked to respond to a brief array of questions about the information presented in the *Nature Science* article, indicating their level of agreement with statements about the reliability of computer models of climate, the bias of scientists, and how convincing they found the results of the study. These responses form a set of 6-point Likert-type items, all of which were later coded as measures of the latent variable "study receptiveness." (A six-point scale was chosen in order to avoid offering subjects a path-of-least-resistance midpoint option, as well as to avoid confusion between potential understandings of the midpoint as “don’t know” versus “no opinion.”) Subjects were also asked to respond to a brief array of questions about their beliefs concerning the risks posed by climate change, and their level of agreement with basic statements about its effects and the need for policy responses, generating a second set of 6-point Likert-type items, all of which were later coded as measures of the latent variable “climate concern.” (The survey questions are itemized in the Appendix.) In essence, the first latent construct summarizes respondents’ openness (or resistance) to new information about climate change, and the second latent construct summarizes the extent to which respondents deem climate change to constitute a threat meriting a policy response. Both of these constructs logically contribute to the political viability (as filtered through elite perceptions) of climate policy proposals.

In addition to the topical questions, the survey also gathered demographic data on respondents’ party ID, educational attainment, age, gender, and region of the country. These were used as control variables in the analytical models described below.

3.4.2 Methodological Concerns

I computed descriptive statistics and applied appropriate statistical tests to the results, as described in the Analysis section below. There is some room here to improve on the methodology employed by Kahan and his colleagues.

First, although all survey questions are Likert-type items, which by their nature produce polytomous, ordinal data, Kahan et al. (2015) utilize different measurement scales for different questions—then conduct z-score normalization of the responses by question, before aggregating them into two composite Likert scales as described above. However, there is substantial controversy in the methodological literature about the legitimacy of treating Likert response items as interval data for analytical purposes (e.g., Kuzon, Urbanchek, and McCabe 1996; Jamieson 2004; Allen and Seaman 2007; Nashimoto and Wright 2007; Norman 2010), since imposing different measurement properties on ordinal data can create interpretational problems. Restructuring and rewording a few of the questions avoids the need to employ a parametric procedure (z-score normalization) on the individual survey items, and also complies with best practices in survey design (Johns 2010; Hartley 2014).

Second, while Kahan and colleagues report the Cronbach's α figures for the composite scale variables, α is properly speaking only a measure of instrument reliability, not of construct validity (Tavakol and Dennick 2011). This leaves open the question of the extent to which the questions asked truly address the constructs of interest. Factor analysis of the composite scales is therefore called for to confirm the unidimensionality of the underlying latent variables. I conducted this factor analysis and validated the relationship between questions and constructs, as detailed below under Results.

Third, Kahan et al. use the composite scales as dependent variables in Ordinary Least-Squares (OLS) regression models to determine the impact of the treatments (and worldviews) on the underlying attitudes. Multivariate regression again rests on assumptions about interval data, and (although commonplace with Likert data in the literature) remains controversial as described above. Some sources (e.g., Norman 2010) maintain that composite Likert *scales* contain interval data, and thus produce valid results from parametric analysis, although individual Likert *items* may not; nonetheless, in addition to replicating the regression approach, I deemed it prudent also to utilize suitable nonparametric tests to verify the robustness of the findings.

Fourth, Kahan et al. create each of their composite scales by taking the arithmetical average of the (standardized) responses, which disregards the possibility that response items may load onto the underlying latent variable with different weights. Using structural equation modeling (SEM) to predict factor scores avoids this problem, is a natural complement to the confirmatory factor analysis (CFA) already described, and creates composite scale data that not only reflects the weight of the individual response items, but takes the form of genuine interval data suitable for parametric analysis. In addition to replicating the arithmetical approach, therefore, I also employed SEM and ran regressions on the scales resulting from the factor scores.

3.4.3 Expectations

Subjects can be expected to come to such a study with strong and divergent beliefs about climate change. It is possible that climate change may be a more salient issue overall for economic elites than for the general public, but this ought not present a source of bias, as the survey was designed to uncover varying levels of elite receptiveness and concern contingent on priming about different policy responses. Note that the comparison to be made here involves different levels of elite opinion contingent on policy approaches, *not* elite opinion versus median public opinion, so a finding in which elite views resemble those of the broader public would not be a null finding but a relevant indicator of political viability. Both composite measures, study receptiveness and climate concern, can be understood to stand in roughly inverse relation to political resistance.

Provisionally, I anticipated that the results for this study of affluent elites would be comparable to those found by Kahan et al. (2015) in regard to the broader public—that is to say, that participants in Group B, exposed to the geoengineering information, would demonstrate (on the first latent construct) greater openness to scientific findings and/or (on the second latent construct) greater concern about the risks of climate change and correspondingly greater openness to policy intervention, at statistically significant levels, than those in Group A, exposed to regulatory proposals. I similarly anticipated that Group B might demonstrate (at statistically significant levels) less-polarized views on the topic than Group A, as did Kahan et al.'s subjects (with the caveat that they were measuring polarization between their worldview groups, designated as "egalitarian communitarians" and "hierarchical individualists," which are at best a very rough proxy for the left-vs.-right political valence ordinarily employed in studies of polarization). The geoengineering treatment connects with beliefs about technological progress, human ingenuity, and innovative problem-solving, but it makes sense only in a context where climate change is acknowledged to be occurring and causing harm. As such, I hypothesized that it should mitigate the effects that political polarization may otherwise have on respondents' attitudes.

3.5 Analysis

Stated succinctly, the goal of this study is to discern the degree to which the attitudes of politically influential economic elites show greater openness on climate issues in the context of geoengineering policy options, rather than traditional regulatory approaches. This openness can be regarded as a proxy for greater political viability in America's current legislative arena. The expected outcome was that economic elite individuals (i.e., those in the top decile of the income distribution) would show significant openness to geoengineering. Respondent attitudes were also measured contingent on control variables including age, gender, party ID, and education. Detailed results of the analysis follow.

Because the survey was cognitively demanding, completion times were checked to confirm respondents' good-faith efforts to engage in the necessary readings and assessments. The median completion time for the survey was three minutes forty seconds; the mean completion time was three minutes sixteen seconds. As completion times less than three minutes are arguably unrealistic, all statistical analyses described below were conducted not only on the full data set (N=568), but also on a reduced data set consisting only of those respondents whose completion times were equal to or greater than three minutes (N=329). While the limited sample size may impose formal constraints on the reliability of the results, in almost all cases those results that showed statistical significance corresponded closely across both data sets.

3.5.1 Results

3.5.1.1 Summary Statistics

The median and mean responses for each survey item, and other standard statistics, are summarized in Table 3.1. Each question had a six-point answer scale, offering "complete," "moderate," and "slight" levels of both agreement and disagreement with the proposition posed.

Note that responses for every question deviate substantially from normality, with skewness levels often above the rule-of-thumb threshold of ±0.5 and kurtosis levels almost always above the threshold of ±1.0. (Note also that the mean is not actually a meaningful value for Likert-type items. For example, in a hypothetical group where half the respondents strongly disagree with a statement, and half strongly agree, the average response is definitely not "no opinion.")

Table 3.1. Summary Statistics for Survey Responses

	Median	Mean	SD	Variance	Skewness	Kurtosis
S1. Study convincing	5	4.35	1.48	2.20	-1.02	3.14
S2. Scientists biased	4	4.08	1.60	2.57	-0.32	1.91
S3. Models reliable	5	4.24	1.44	2.07	-0.82	2.91
S4. More studies needed	3	3.06	1.88	3.53	0.37	1.63
C1. Temps increasing	6	4.81	1.67	2.78	-1.15	2.90
C2. Human caused	6	4.69	1.76	3.09	-1.07	2.70
C3. Bad consequences	6	4.81	1.72	2.97	-1.23	3.07
C4. Policy action now	6	5.09	1.47	2.16	-1.68	4.73

(Response range: 1-6)

Four survey items address the first latent construct, *study receptiveness*, indicating how open respondents are to scientific information about climate change by gauging responses to the composite *NatureScience* article. From the reduced data set, for the first study-related question (let us call it Question S1), "In your view, how convincing was the study," the median value was 5 ("moderately convincing"), and 58.97% of respondents found it either moderately or completely convincing.

For Question S2, “The scientists who did the study were biased,” the median from the reduced data set was 4 (“moderately disagree”), and 46.20% of respondents either moderately or completely disagreed.

For Question S3, “Computer models like those used in the study are a reliable way of predicting the impact of CO_2 on the climate,” the median was 5 (“moderately agree”), and 51.67% of respondents either moderately or completely agreed.

For Question S4, “Before policymakers can rely on findings like these, more studies must be done,” the median was 3 (“slightly agree”), and 49.54% of respondents either moderately or completely agreed, while only 29.48% of respondents moderately or completely disagreed. These results seem somewhat at odds with the other three, in that they indicate greater skepticism about the reliability of the science. However, it’s theoretically possible to interpret the question differently—in that some respondents who *accept* the current state of knowledge about climate change would still find additional scientific research valuable—which somewhat complicates interpretation of the results on this question.

The full range of responses for each question is summarized in Table 3.2. (From the full data set, disregarding response times, the QS1 median was also 5, and 54.22% found it either moderately or completely convincing. The QS2 median was 4, and 41.20% of respondents either moderately or completely disagreed. The QS3 median was 4, and 47.36% either moderately or completely agreed. The QS4 median was 3, and 46.65% of respondents either moderately or strongly agreed that more studies are needed, while only 26.58% moderately or strongly disagreed. Clearly, in each instance including the “faster” responses reduced the overall level of acknowledgement of the science by a few percentage points, but only a few.)

Table 3.2. Detailed Survey Responses—Study Receptiveness

	1	2	3	4	5	6
S1. Study convincing	Completely unconv. **8.80%**	Moderately unconv. **6.87%**	Slightly unconv. **8.45%**	Slightly conv. **21.65%**	Moderately conv. **34.33%**	Completely conv. **19.89%**
S2. Scientists biased	Strongly agree **8.10%**	Moderately agree **13.03%**	Slightly agree **21.83%**	Slightly disagree **15.85%**	Moderately disagree **18.66%**	Completely disagree **22.54%**
S3. Models reliable	Strongly disagree **8.45%**	Moderately disagree **6.69%**	Slightly disagree **12.32%**	Slightly agree **25.18%**	Moderately agree **29.58%**	Strongly agree **17.78%**
S4. More studies needed	Strongly agree **26.23%**	Moderately agree **20.42%**	Slightly agree **14.61%**	Slightly disagree **12.15%**	Moderately disagree **11.97%**	Completely disagree **14.61%**

(all respondents)

Four other survey items address the second latent construct, *climate concern*, indicating the extent to which respondents are concerned about the risks of climate change and consider it a problem meriting a policy response. From the reduced data set, for Question C1, "Average global temperatures are increasing," the median response was 6 ("strongly agree"), and 68.90% of respondents either moderately or strongly agreed.

For Question C2, "Human activity is causing global climate change," the median was again 6 ("strongly agree"), and 64.94% of respondents either moderately or strongly agreed.

For Question C3, "Climate change is likely to cause bad consequences for human health, safety, and prosperity," the median was again 6 ("strongly agree"), and 69.82% of respondents either moderately or strongly agreed.

For Question C4, "In your view, how important is it for policymakers to take steps now to counteract climate change?," the median was once again 6 ("very important"), and fully 77.44% of respondents either moderately or strongly concurred.

The full range of responses for each question is summarized in Table 3.3. (From the full data set, the QC1 median was also 6, and 66.78% of respondents moderately or strongly agreed. The QC2 median was also 6, and 63.61% of respondents moderately or strongly agreed. The QC3 median was also 6, and 67.84% of respondents moderately or strongly agreed. The QC4 median was also 6, and 73.14% of respondents found policy action moderately or strongly important. Again, the differences from the reduced data set are minimal.)

Table 3.3. Detailed Survey Responses—Climate Concern

	1	2	3	4	5	6
C1. Temps increasing	Strongly disagree **5.65%**	Moderately disagree **9.72%**	Slightly disagree **6.18%**	Slightly agree **11.66%**	Moderately agree **12.01%**	Strongly agree **54.77%**
C2. Human caused	Strongly disagree **9.89%**	Moderately disagree **7.24%**	Slightly disagree **5.83%**	Slightly agree **13.43%**	Moderately agree **11.84%**	Strongly agree **51.77%**
C3. Bad consequences	Strongly disagree **9.01%**	Moderately disagree **6.54%**	Slightly disagree **5.83%**	Slightly agree **10.78%**	Moderately agree **12.72%**	Strongly agree **55.12%**
C4. Policy action now	Not at all important **6.18%**	Moderately unimportant **5.12%**	Slightly unimportant **3.71%**	Slightly important **11.84%**	Moderately important **15.72%**	Extremely important **57.42%**

(all respondents)

3.5.1.2 Nonparametric Tests

As they contain strictly ordinal data, the individual survey items are not susceptible to parametric tests, which typically have greater statistical power but require interval data. However, before moving on to the composite, latent variables, which are in interval form, it can be instructive to subject the individual survey items to some nonparametric analysis.

The objective is to split the respondents into two groups, depending on which treatment they were exposed to (regulation or geoengineering), and compare the responses of those two groups. The Mann-Whitney *U* Test is useful to compare two groups, while the Kruskal-Wallis *H* Test is useful for two or more groups. Neither depends on the parameters of the sample distribution, and in each case the null hypothesis is that the samples originate from statistically indistinguishable population distributions.

The Mann-Whitney test shows statistically significant differences (at the $\alpha=0.05$ level) between treatment groups only for Question S3 (“computer models are reliable”), $p=0.0363$, and Question S4 (“more studies are needed”), $p=0.0067$.

The Kruskal-Wallis test produces the same results, also showing statistically significant differences (at the α=0.05 level) between treatment groups only for Question S3 ("computer models are reliable"), $x^2(1)=4.381$, $p=0.0363$, and Question S4 ("more studies are needed"), $x^2(1)=7.345$, $p=0.0067$.

(Tests on the full data set concur with these results, but also show a statistically significant difference between treatment groups for Question S1 ("study was convincing").)

3.5.1.3 Exploratory Factor Analysis

Of course, the goal of the study goes beyond these basic tests on individual survey items, and involves analyzing the latent constructs the questions are meant to reveal. Rather than accept at face value the constructs proffered by Kahan et al. (2015), it seems reasonable to start by conducting an exploratory factor analysis (EFA) to see whether and how the survey questions load onto underlying constructs, especially since the survey has been slightly modified from the version in the literature, as described above.

Standard methods of EFA utilize a Pearson correlation matrix, which assumes that variables are continuous, and thus produces unreliable results for ordinal data. However, it's possible to circumvent this obstacle by instead using a polychoric correlation matrix (Gaskin and Happel 2014). Taking this approach and then running an EFA on all eight substantive questions in the reduced data set produces the result shown in Table 3.4 (with Varimax factor rotation and loadings under 0.45 suppressed).

The first set of questions load well onto one factor and the second set onto another with clear statistical significance ($p<0.0001$), and these two factors combined account well for the observed variance (cumulative proportion = 1.0447)—over 100%, resulting from the fact that there is some modest correlation between the factors. Question C4 loads well onto both factors. We can also observe that Question S4 has the weakest loading onto the first factor. This makes sense given that this variable is slightly different from the others, with possible multiple interpretations of the question as discussed above. (EFA conducted on the full data set produces comparable results on all fronts.)

Table 3.4. Polychoric Exploratory Factor Analysis

```
Factor analysis/correlation                        Number of obs    =        328
    Method: principal factors                      Retained factors =          3
    Rotation: orthogonal varimax (Kaiser off)      Number of params =         21

    --------------------------------------------------------------------------
         Factor  |     Variance   Difference        Proportion   Cumulative
    -------------+------------------------------------------------------------
        Factor1  |      3.32688      1.06427            0.6127       0.6127
        Factor2  |      2.26261      2.10907            0.4167       1.0294
        Factor3  |      0.15354            .            0.0283       1.0577
    --------------------------------------------------------------------------
    LR test: independent vs. saturated:  chi2(28) = 2286.74 Prob>chi2 = 0.0000

Rotated factor loadings (pattern matrix) and unique variances

    -----------------------------------------------------------
        Variable |  Factor1   Factor2   Factor3 |   Uniqueness
    -------------+------------------------------+--------------
         studyQ1 |   0.4034    0.7171    0.0167 |      0.3228
         studyQ2 |   0.5066    0.6347    0.1719 |      0.3109
         studyQ3 |   0.4987    0.6702    0.0843 |      0.2950
         studyQ4 |   0.3709    0.4705    0.2569 |      0.5751
        crisisQ1 |   0.7578    0.3176    0.1637 |      0.2980
        crisisQ2 |   0.8684    0.3555    0.0447 |      0.1175
        crisisQ3 |   0.8678    0.3510    0.0624 |      0.1199
        crisisQ4 |   0.6631    0.5697    0.1339 |      0.2179
    -----------------------------------------------------------
```
(reduced data set)

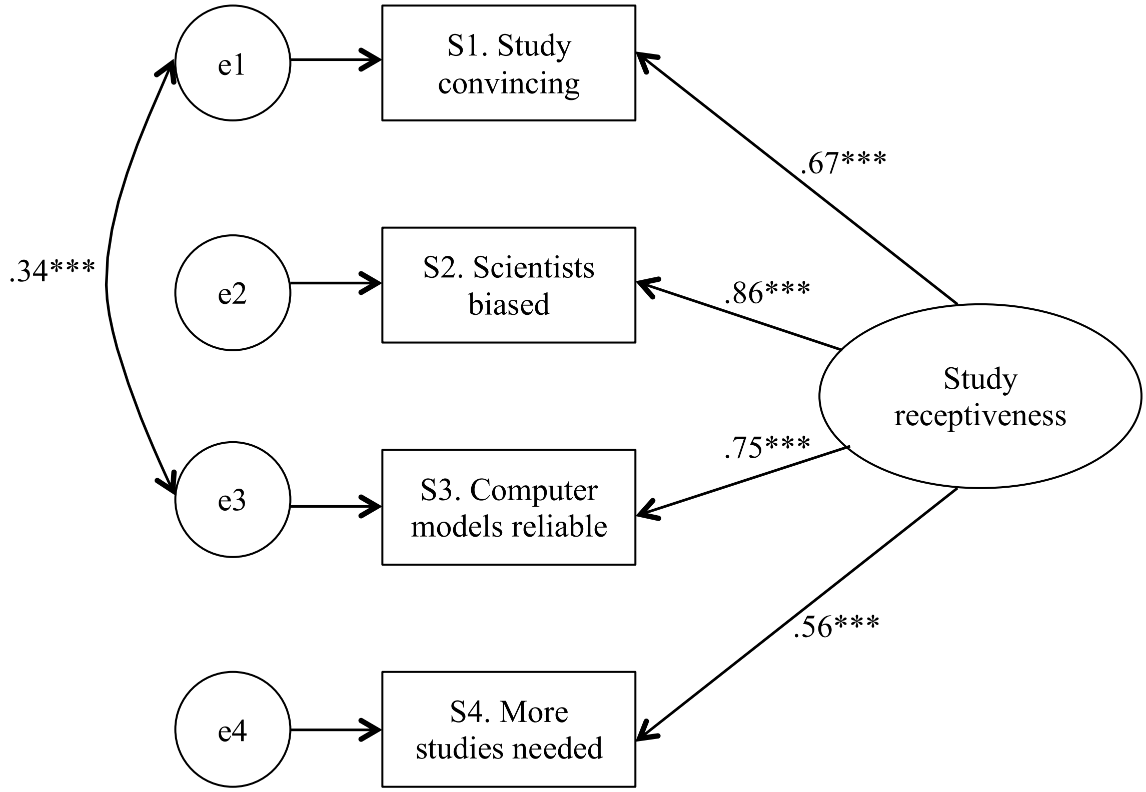
3.5.1.4 Confirmatory Factor Analysis

Confirmatory factor analysis (CFA) could legitimately be conducted without EFA as a prior step, but the EFA helps to affirm the underlying assumptions of the survey in the most basic terms, including the existence of two latent variables, on the basis of data alone. CFA is less lenient, and evaluates a specific model of those latent variables grounded in *a priori* theory—estimating only the paths that link each observed variable to its corresponding latent factor—in order to measure the model's goodness of fit and thereby establish unidimensionality and construct validity.

With CFA, the null hypothesis is that the model works, so the first goal is to avoid a statistically significant *p*-value; a significant result indicates that there may be missing paths in the model's specification. That being the case, it is cause for concern that the CFA results for the simplest structure for the first latent factor, *study receptiveness*—modeling it on all four response items (S1-S4)—produces a *p*-value of 0.0009. It also has a root mean squared error of approximation (RMSEA) of 0.112, whereas the optimal level is <0.05 and the acceptable level is <0.1 (Awang 2012). As a possible cause, however, the modification indices show a high covariance between the error terms of Questions S1 and S3. This is reasonable: there's a conceptual link between finding a study convincing and finding its modeling techniques reliable.

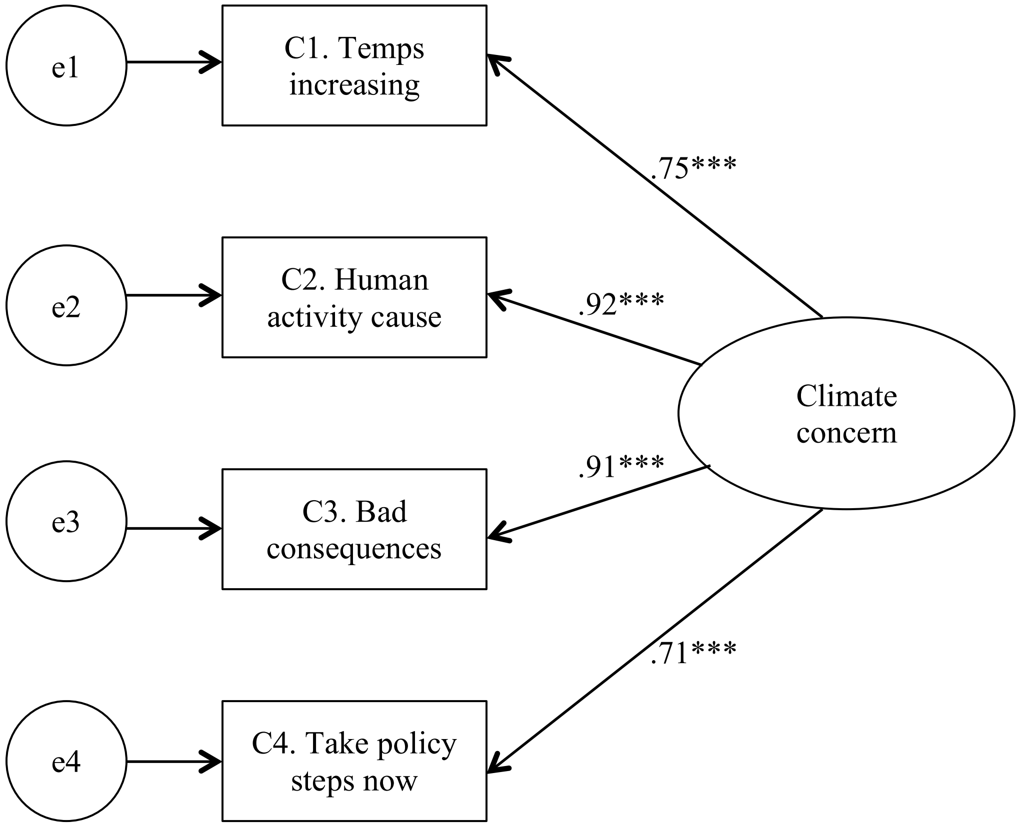
When this connection is incorporated into the model, the results are acceptable. All factor loading coefficients—the correlations between the observed measurements and the latent factor—exceed 0.5, signifying unidimensionality (although S4 is still a moderate outlier at only 0.56). The *p*-value adjusts to 0.0501, and the RMSEA to 0.093, within the margins of acceptable construct validity. Additional corroboration comes from the comparative fit index (CFI) measure of 0.994 and the Tucker-Lewis Index (TLI) measure of 0.965 (desirable thresholds are >0.95 and >0.90 respectively). The path diagram for the model is shown in Figure 3.1.

Figure 3.1. CFA Path Diagram for Study Receptiveness



The results for the second latent factor, climate concern, present even fewer complications. Modeling it on all four response items (C1-C4), the CFA produces a *p*-value of 0.6361, a RMSEA of 0.000, a CFI of 1.000, and a TLI of 1.004. All factor loading coefficients are well above 0.5. There is no question of goodness of fit. The path diagram for the model is shown in Figure 3.2.

Figure 3.2. CFA Path Diagram for Climate Concern



(The results for CFA on the entire data set, rather than the reduced data set contingent on response times, vary in the particulars but match in the relevant results: latent variable *climate concern* shows satisfactory goodness-of-fit measurements when modeled simply on all four response items (C1-C4), whereas latent variable s*tudy receptiveness* only shows satisfactory fit when the model incorporates error covariance between items S1 and S3).

3.5.1.5 Structural Equation Modeling

While CFA validates the "measurement model" for latent variables, it is only one component of structural equation modeling (SEM), which is similar to but more powerful than traditional multiple regression, capable of measuring latent variables, correlations, nonlinear relationships, and more. After confirming the measurement model, it is not uncommon to construct a comprehensive "simultaneous estimation model" that incorporates additional variables into the

SEM as submodels (structural components), and/or models relationships among the validated latent variables. However, simultaneous estimation is often not feasible when a model contains both continuous and ordinal variables and/or the SEM is conducted using maximum likelihood estimation—both of which conditions apply here—among other circumstances; the former can lead to intractable calculation problems and the latter to substantial bias and misspecification of the measurements (Hoshino and Bentler 2011).

In the case at hand, simultaneous estimation does indeed seem to be infeasible or, at least, not germane. Several theoretically grounded attempts to incorporate the two validated latent variables in a single model, either in relation to one another or as indicators of a single unifying latent variable, failed to produce any statistically meaningful results. Fortunately, that approach is not actually necessary in the case at hand, as the study does not hinge on integrating the two latent constructs.

In the alternative, a simpler method that is sometimes employed is "item parceling," which merely sums or averages the values of the observed variables in each latent construct, and uses those composite scores as the values of dependent (latent) variables, either in a structural model or in regression models, to estimate the effect of additional variables. This is the approach taken to construct the composite variables in Kahan et al. (2015). However, it necessarily discards much of the information obtained through the CFA, and is prone to producing biased, underestimated, and/or unstable estimates (Hoshino and Bentler 2011).

Fortunately, there is another alternative. A middle-ground approach is a multistep estimation procedure, using the validated measurement model(s) to predict "factor scores" for the latent variables(s), estimating them as *weighted* composites of the observed measurements rather than as simples sums or averages. Weights are based on the amount of common variance in each measurement. These factor scores are new continuous variables, with values for each individual observation (i.e., survey response). They are then used as dependent variables in traditional parametric analyses—commonly regression models, hence the term “factor score regression.” Factor scores are not immune to bias, as they are linear combinations of other variables and hence contain error, but the process nonetheless can avoid the problems of both simultaneous estimation and item parceling.

I used this procedure in the study at hand, predicting factor scores based on the validated CFAs. These can be seen in Tables 3.5 and 3.6 and Figures 3.3 and 3.4. They are standardized, continuous variables, with means very closely approximating zero and standard deviations roughly approaching 1.0, but they still demonstrate substantial levels of skewness and kurtosis.

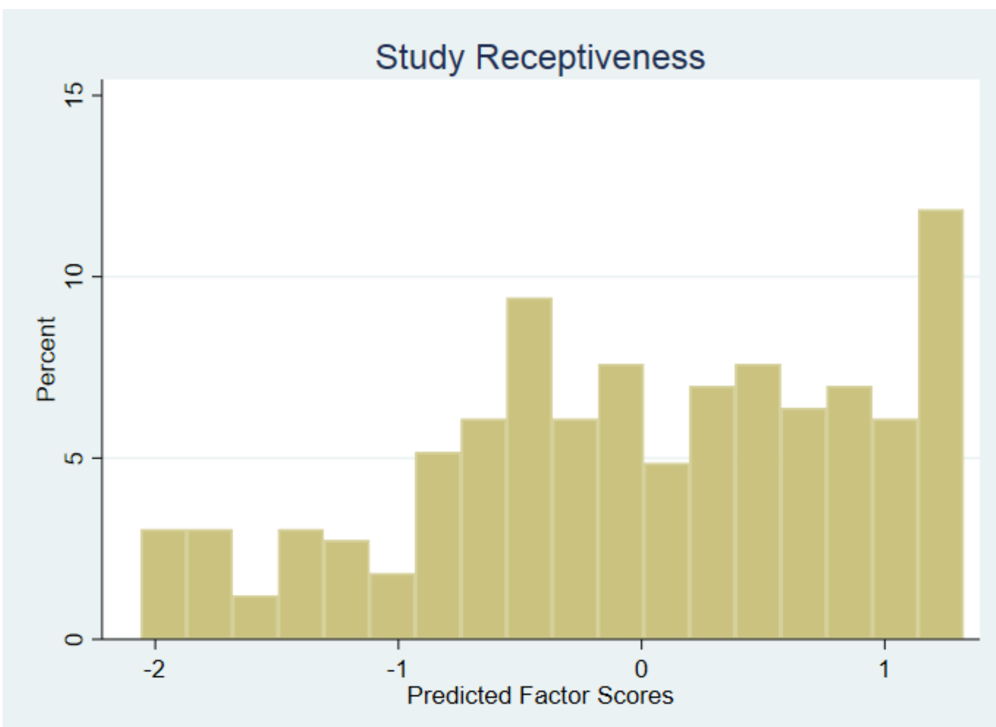
Table 3.5. Summary of Study Receptiveness Factor Scores

```
                     Factor scores (STUDY RECEPTIVENESS)
-------------------------------------------------------------
      Percentiles      Smallest
 1%    -2.058405      -2.058405
 5%    -1.708473      -2.058405
10%    -1.308695      -2.058405       Obs                 329
25%    -.5988725      -2.058405       Sum of Wgt.         329

50%     .0615553                      Mean          -4.95e-09
                        Largest       Std. Dev.      .9057544
75%     .7543865       1.324743
90%     1.161592       1.324743       Variance        .820391
95%     1.324743       1.324743       Skewness      -.3881556
99%     1.324743       1.324743       Kurtosis       2.330125
```

(reduced data set)

Figure 3.3. Histogram of Study Receptiveness Factor Scores



x

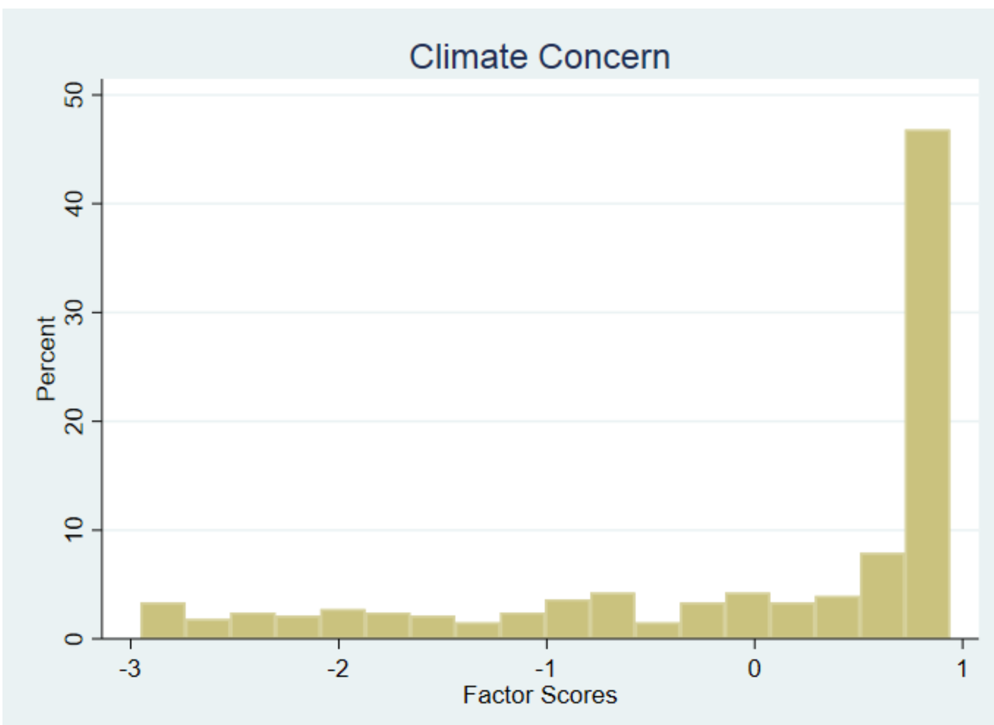
Table 3.6. Summary of Climate Concern Factor Scores

```
                    Factor scores (CLIMATE CONCERN)
-------------------------------------------------------------
      Percentiles      Smallest
 1%    -2.953269      -2.953269
 5%    -2.575859      -2.953269
10%    -2.000923      -2.953269       Obs                 329
25%     -.712542      -2.953269       Sum of Wgt.         329

50%     .6212927                      Mean           8.06e-09
                        Largest       Std. Dev.      1.202828
75%     .9385297       .9385297
90%     .9385297       .9385297       Variance       1.446795
95%     .9385297       .9385297       Skewness      -1.082903
99%     .9385297       .9385297       Kurtosis       2.840746
```

(reduced data set)

Figure 3.4. Histogram of Climate Concern Factor Scores



3.5.1.6 Parametric Tests

As a precursor to running regressions on the *Study* and *Climate* constructs, I first conducted *t*-tests and ANOVA to compare the parameters of each set of scores as divided by treatment groups (for regulation and geoengineering respectively), as well as by each of the demographic control variables. The treatment never rises to the level of statistical significance in any instance, although it is almost significant in the *t*-test for the *Study* construct, albeit only at the α=0.10 level (with a *p*-value of 0.1068). Among the control variables, however, both party ID and gender prove to be significant. (When conducted on the full data set, the treatment crosses the boundary into significance on the *t*-test, with a *p*-value of 0.0886.)

Multivariate factor score regression reinforces these findings. In the full model (incorporating the treatment and all relevant control variables), and then in progressively reduced models, party ID and gender are the only independent variables with statistically significant effects on either latent construct. While the explanatory power of the fitted models is not especially high (with an adjusted R^2 = 0.165 for *study receptiveness*, .218 for *climate concern*), it is still noteworthy, as this is an exercise in seeking a faint signal amidst considerable noise. (Factor score regressions using the full data set do not deviate from these results, although of course the precise coefficients are slightly different.) See Tables 3.7 and 3.8, and Figures 3.5a-c and 3.6a-c, for details. Note that party ID can be further disaggregated, if treated as a categorical variable, to show the marginal effects of each shift in degree of partisanship.

Table 3.7. Regression Models and Results for *Study Receptiveness*

Study Receptiveness

	Model 1	Model 2	Model 3
Treatment (geo)	-.125 (.094)	-.112 (.093)	
Party ID	**-.176*** (.028)	**-.175*** (.028)	**-.179*** (.028)
Gender	**.304*** (.100)	**.305*** (.099)	**.291*** (.099)
Education	-.030 (.042)		
Age	.039 (.050)		
Income	-.088 (.099)		
Constant	1.25 (1.03)	.376 (.229)	.238 (.198)
R^2	.179	.174	.170
Adj. R^2	.163	.166	.165
F-test	(6, 318) **11.52***	(3, 321) **22.55***	(2, 322) **33.05***

Note: N=325. Standard errors in parentheses. **Bold** typeface denotes that the indicated regression coefficient or *F*-test is statistically significant at $p<0.05$; * denotes $p<0.01$.

Table 3.8. Regression Models and Results for *Climate Concern*

Climate Concern

	Model 1	Model 2	Model 3
Treatment (geo)	-.087 (.121)	-.088 (.120)	
Party ID	**-.289*** (.037)	**-.292*** (.036)	**-.295*** (.036)
Gender	**.315** (.129)	**.314** (.128)	**.303** (.127)
Education	.022 (.054)		
Age	-.013 (.065)		
Income	-.142 (.128)		
Constant	2.06 (1.33)	**.751** (.294)	**.642** (.254)
R^2	.227	.224	.223
Adj. R^2	.213	.217	.218
F-test	(6, 318) **15.58***	(3, 321) **30.86***	(2, 322) **46.08***

Note: N=325. Standard errors in parentheses. **Bold** typeface denotes that the indicated regression coefficient or *F*-test is statistically significant at $p<0.05$; * denotes $p<0.01$.

Figure 3.5a. Study Receptiveness and Party ID

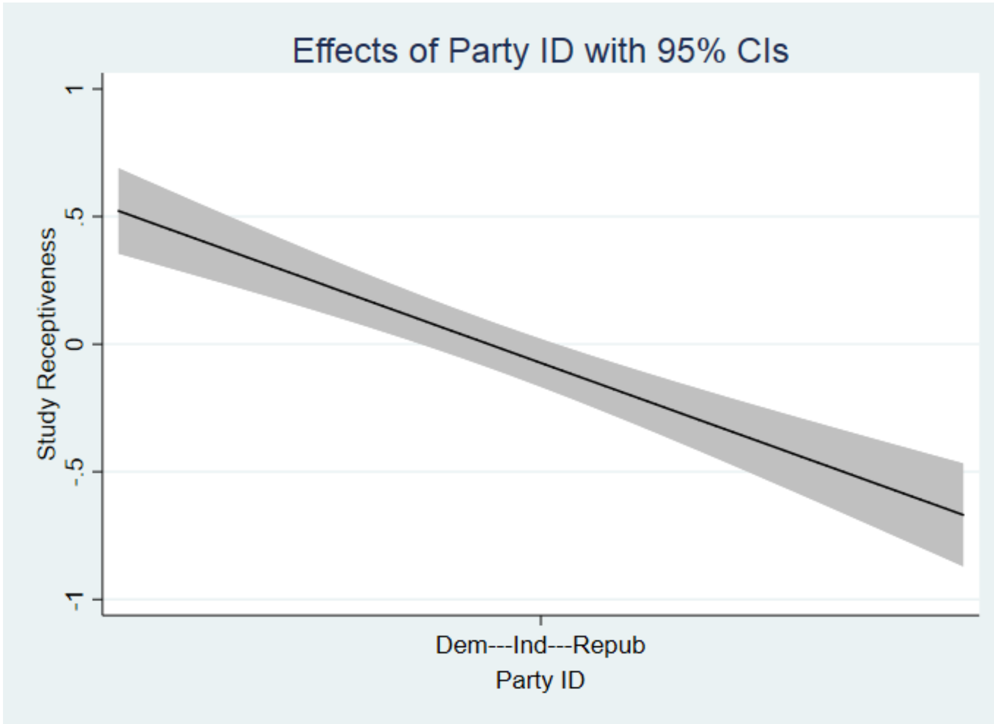


Figure 3.5b. Study Receptiveness and Party ID (marginal effects by category)

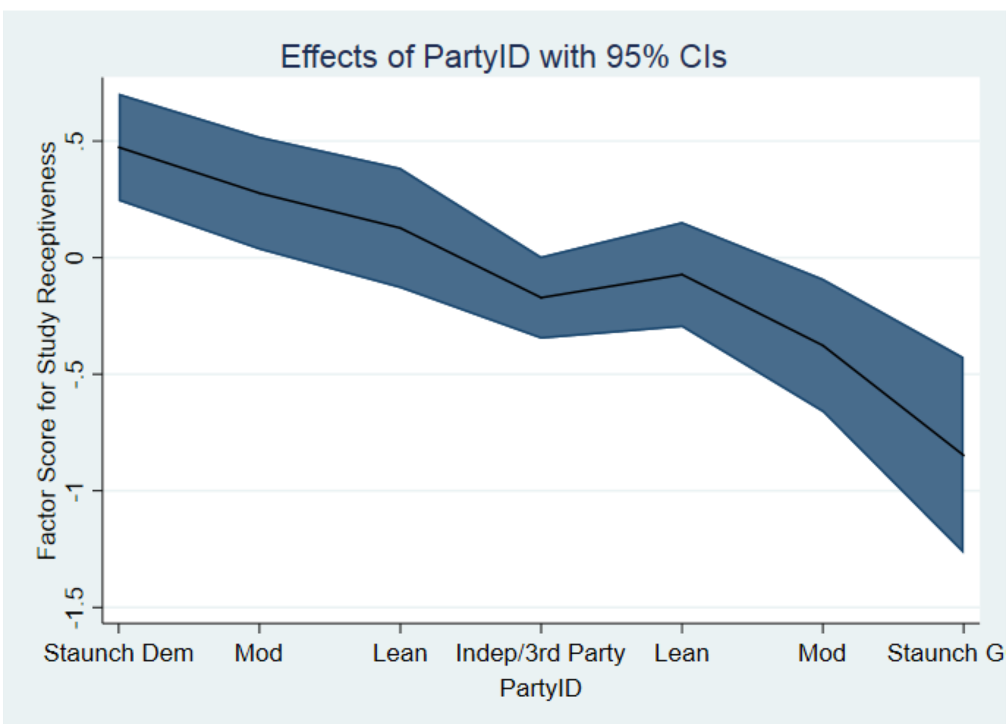


Figure 3.5c. Study Receptiveness and Gender

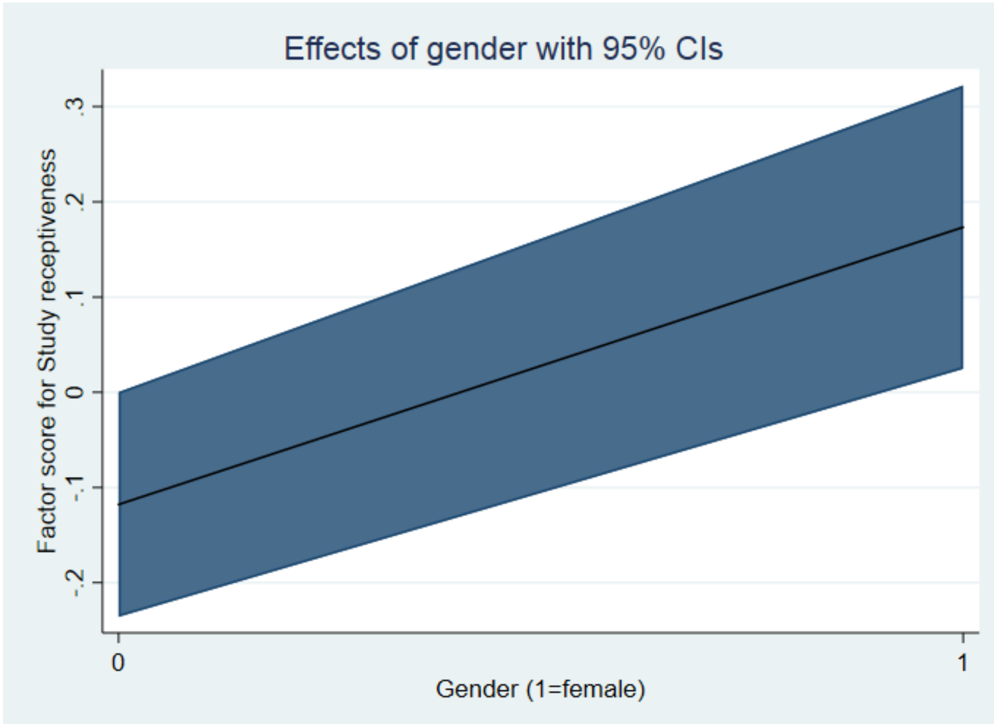


Figure 3.6a. Climate Concern and Party ID

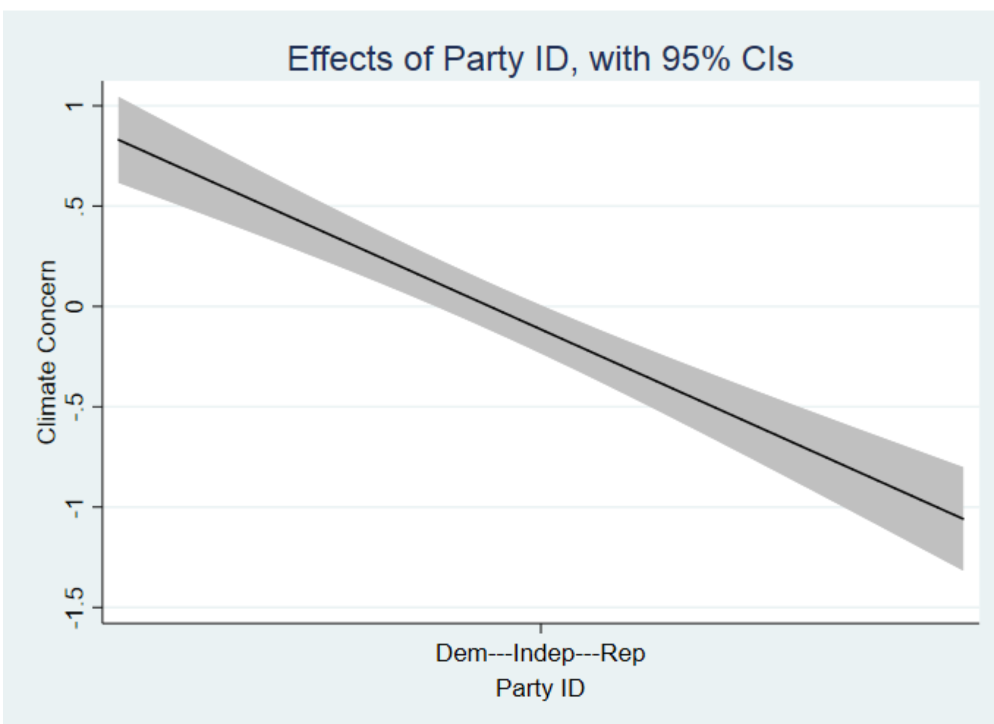


Figure 3.6b. Climate Concern and Party ID (marginal effects by category)

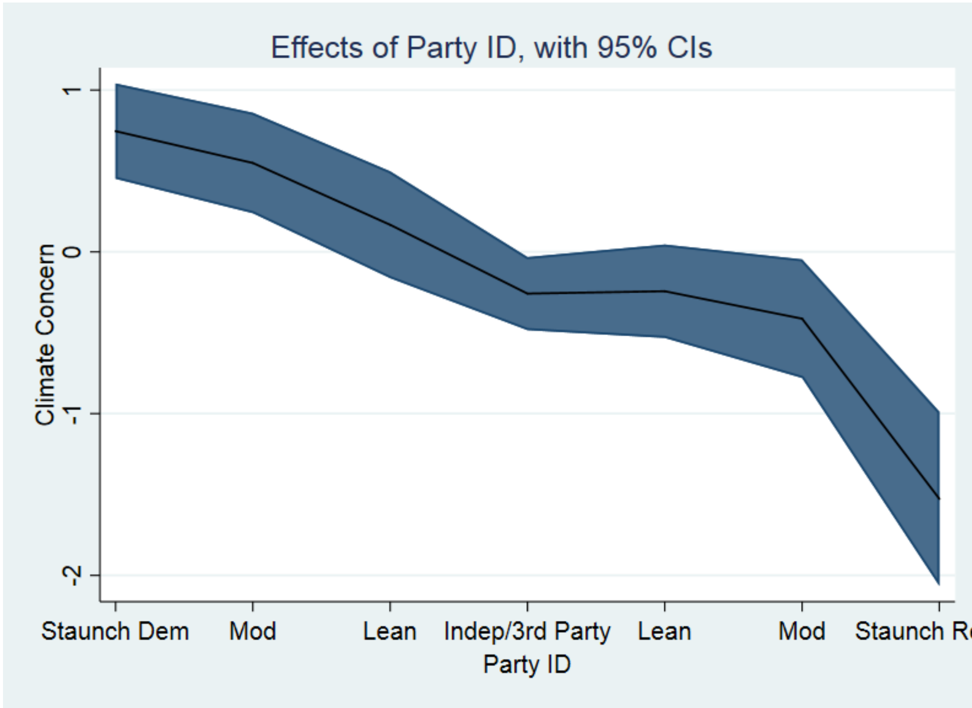
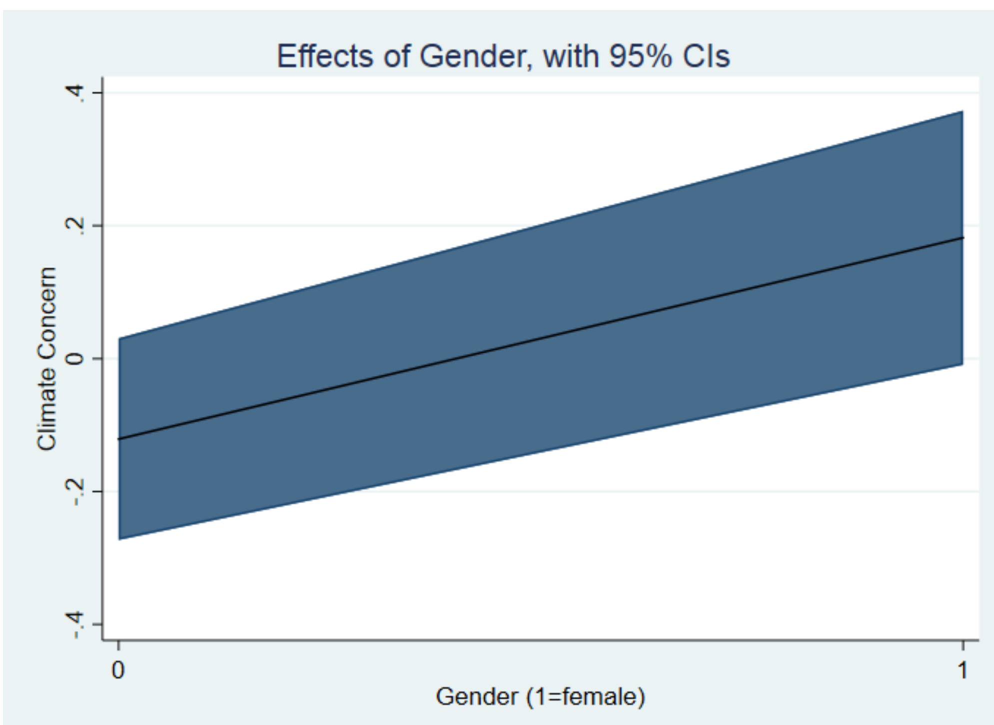


Figure 3.6c. Climate Concern and Gender



3.6 Discussion

Contrary to hypothesized expectations, this study clearly suggests that priming and framing climate-related information in terms of geoengineering as opposed to regulation *does not* have a statistically significant impact on the attitudes of economic elites. It makes no difference in terms of either receptiveness to scientific information, or concern about the risks and impacts of climate change.

One may still posit resistance from economic elites as the thumb on the scales obstructing climate policy action in the United States. However, the evidence at hand does not support the proposition that reframing public communications on the issue to focus on technologically innovative solutions like geoengineering—rather than regulatory trade-offs—will help mitigate that resistance.

Critically, though, that may not be an accurate manner in which to characterize the resistance to climate policy. Without in any way diminishing the effects of growing economic inequality and the consequent imbalance in political representation, which is well-documented in the literature, it appears that the main reason it is not a factor in this context is that at this point in the evolution of the issue domain, climate change is highly salient to economic elites *regardless* of how potential policy responses are framed, and thus elite attitudes are not at odds with those of the larger population, but congruent with them.

After all, the results of this study show clearly that regardless of treatment group, majorities of respondents are receptive to the science, and even stronger majorities are concerned about the causes and effects of climate change and the need for policy responses. This is every bit as clear from the individual survey items as it is from the latent scales constructed from them.

This might seem an encouraging indicator… yet nonetheless, it remains self-evidently true that no serious policy action to address climate change has emerged from Congress in recent years. Other undetermined factors may account for this, but contrary to expectations drawn from the literature on representational inequality, it does not appear to be a response to the preferences of legislators' most affluent (and hence influential) constituents.

The data at hand points to an answer, and it lies not in inequality but in the other long-term trend that motivated this research: partisan polarization. While economic elites *in aggregate* apparently want to see action on the climate crisis, after all, the data analysis clearly shows that the most (and almost only) significant variable dividing that group is party identification.

While factor scores have no natural units, they are scaled according to the first-loading indicator variable, which is to say that they represent the spread from one extreme (complete agreement) to the other (complete disagreement), expressed as a continuous range. And the magnitude of the partisan effect is dramatic for scientific receptiveness, and even more so for climate concern, at a confidence level of greater than 99%. Respondents who lean Republican are strongly inclined toward climate skepticism. No other variable is equally significant. Education plays no detectable role at all. Gender does, with women expressing greater receptiveness and concern than men, but gender has vastly more mediating variables between it and political behavior than does party ID.

It seems unfortunately clear, then, that the effects of partisan polarization currently supersede the attempt to reframe policy options within the climate domain, and contribute to strong levels of political resistance even in the face of economic elite influence. It is not immediately obvious how this reconciles with the findings of work such as Kahan et al. (2015), indicating that a geoengineering frame helps to reduce polarization. The difference in findings may be a result (however counterintuitive) of the fact that this study examines economic elites rather than the public at large. It may be an artifact of the way Kahan et al. measure polarization, as the distance between two attitude clusters that are not necessarily correlated with party identification. It may be an artifact of methodological differences in measuring survey responses, as described above. Or it may simply be an artifact of change over time (albeit less than a decade) since that study was conducted.

One thing more is clear: both economic inequality and ideological polarization are fast-moving targets, and the long-term transformations they imply are far from finished. Further research is called for, both to clarify the breadth and depth of the effects of polarization, and to consider other means of minimizing or circumventing it.

For the time being, at least, it remains true that geoengineering *per se* has not yet been leveraged as a wedge issue, and does not prompt political resistance in its own regard that is in any way distinguishable from the resistance to climate policy more broadly. (I.e., the geoengineering treatment is not statistically significant.) Note also that notwithstanding the overall partisan divide in the results, the factor scores derived from this survey for the "climate concern" construct skew considerably more positive than for the "study receptiveness" construct, suggesting a level of concern about the issue that exceeds openness to conventional expertise. At this juncture, partisan political resistance on climate holds the advantage of a status quo bias toward inaction among policymakers, but it does not represent majority opinion, among either the general public or especially economic elites. Hence, the possibility remains that if geoengineering can be positioned as an alternative distinct from the familiar climate policy domain, and if that difference offers appeal to other interests of influential economic elites, political resistance might feasibly be circumvented.

3.7 Appendix

3.7.A1. Survey Questions: Defining Terms and Variables

Type	Variable	Description
Dependent Variables (Likert scales)	*Study Receptiveness*	Composite scale indicating respondent's inclination to believe the scientific article excerpt about climate change risks
Questions *(Likert-type items)*	**Convinced**	*In your view, how convincing was the study?* (Six-point scale, ranging from "completely unconvincing" to "completely convincing.")
	Bias	*The scientists who did the study were biased.* (Six point scale, ranging from "strongly disagree" to "strongly agree," reverse-coded.)
	Computers	*Computer models like those used in the study are a reliable way of predicting the impact of CO_2 on the climate.* (Six point scale, ranging from "strongly disagree" to "strongly agree.")
	Data	*Before policymakers can rely on findings like these, more studies must be done.* (Six point scale, ranging from "strongly disagree" to "strongly agree," reverse-coded.)
	Climate Concern	Composite scale indicating respondent's overall impression of the seriousness of climate change as a policy problem.
Questions *(Likert-type items)*	**Real**	*Average global temperatures are increasing.* (Six point scale, ranging from "strongly disagree" to "strongly agree.")
	Human	*Human activity is causing global climate change.* (Six point scale, ranging from "strongly disagree" to "strongly agree.")
	Impact	*Climate change is likely to cause bad consequences for human health, safety, and prosperity.* (Six point scale, ranging from "strongly disagree" to "strongly agree.")
	Risk	*In your view, how important is it for policymakers to take steps now to counteract climate change?* (Six point scale, ranging from "Extremely important" to "Not at all important," reverse-coded.)
Independent Variable (Treatment groups)	Regulation (Group A)	Respondents exposed to article in which scientific group calls for strict controls on CO_2 emissions
	Geoengineering (Group B)	Respondents exposed to article in which scientific group calls for increased research into geoengineering
Filtering Variable	Economic status	0 = below 90th income percentile; 1 = 90th percentile or above
Control Variables	PartyID	What political party do you identify with? (Seven point scale, ranging from “Staunch Democrat” to “Staunch Republican.”)
	Education	*What is the highest level of education you have completed?* (Seven point scale, ranging from “Less than HS diploma” to “Ph.D.”)
	Age	*What is your age?* (Five point scale: <18, 18029, 30-44, 45-60, >60)
	Gender	0 = Male, 1 = Female

3.7.A2 Treatment Instruments

A2.1 Regulation Group

Scientists: Even Stricter Anti-Pollution Regulations Needed to Fight Climate Change

New study finds proposed CO2-emission targets will be ineffective

by Andrew Taylor
April 21, 2018

WASHINGTON, D.C. Staving off the catastrophic effects of global warming will require industrialized countries to enact anti-pollution regulations even stricter than ones proposed by the United Nations, a group of expert scientists announced today.

The group, The American Academy of Geophysical Scientists, based this conclusion on a new study finding the environmental impact of human carbon dioxide (CO_2) emissions is likely to be significantly more severe than previously estimated.

The study was conducted by researchers from the Massachusetts Institute of Technology who were unaffiliated with AAGS and who published their findings earlier this year in the journal *Nature Science.*

"Before this study," said AAGS spokesman Dr. Alan M. Williams of Harvard University, "the scientific community assumed it would be enough to gradually slow down and then stabilize CO_2 emissions at 450-600 parts per million," a target approved by the United Nations in 2006. "But the data and computer simulations published by this research team in *Nature Science* show that this strategy will be completely ineffective," Dr. Williams said.

"Even if we somehow stopped emitting CO_2 into the atmosphere today," Dr. Williams told reporters, "the *Nature Science* study shows there would be irreversible and devastating effects on the earth's climate."

The AAGS report states that the *Nature Science* study "supports only one conclusion: cutbacks on carbon emissions will have to be much more drastic than anyone previously believed." As a result, "it will be necessary for industrialized societies to enact much more drastic anti-pollution controls," the AAGS report concludes.

"World governments have a wide range of pollution- cutting tools at their command – 'cap and trade,' fuel taxes, restrictions on the production and use of electricity, subsidies for solar power," said Dr. Williams. "It's time to use them."

Industrialized nations such as the United States and Great Britain have so far balked at adopting policies deemed essential to meeting the U.N.'s 450-600 ppm target because of concerns over the burdens such measures would inflict on businesses and consumers. The even lower CO_2 ceiling proposed by the AAGS – 175 ppm – could impose even larger costs, the report acknowledged.

"Yes, we will all need to make sacrifices," stated Williams in a press conference announcing the AAGS report. "It's precisely because the residents of industrialized countries have for decades insisted on a standard of living that exceeds the capacities of the natural environment that we are in this mess," Williams told an assembly of reporters in Washington, D.C.

CO_2 emissions and climate change. Recent study suggests that CO_2 emissions from power plants and other sources will cause "irreversible" damage to the environment even at levels proposed by the U.N. On this basis, AAGS has called for even stricter anti-pollution regulations. (Credit: AAGS Report, "Climate Change: The Urgent Need to Cut Back.")

Scientists: More Technology, Not More Limits, Needed to Fight Climate Change

New study finds proposed CO_2-emission limits will be ineffective

by Andrew Taylor

April 21, 2018

WASHINGTON, D.C. Staving off the catastrophic effects of global warming will require industrialized countries to shift their emphasis from anti-emission regulations to new "geoengineering" technologies aimed at counteracting the effects of climate change, a group of expert scientists announced today.

The group, the American Academy of Geophysical Scientists, based this conclusion on a new study finding the environmental impact of human carbon dioxide (CO_2) emissions is likely to be significantly more severe than previously estimated.

The study was conducted by researchers from the Massachusetts Institute of Technology who were unaffiliated with AAGS and who published their findings earlier this year in the journal *Nature Science.*

"Before this study," said AAGS spokesman Dr. Alan M. Williams of Harvard University, "the scientific community assumed it would be enough to gradually slow down and then stabilize CO_2 emissions at 450-600 parts per million," a target approved by the United Nations in 2006. But the data and computer models published by this research team in *Nature Science* show that this strategy will be completely ineffective," Dr. Williams said.

"Even if we somehow stopped emitting CO_2 into the atmosphere today," Dr. Williams told reporters, "the *Nature Science* study shows there would be irreversible and devastating effects on the earth's climate."

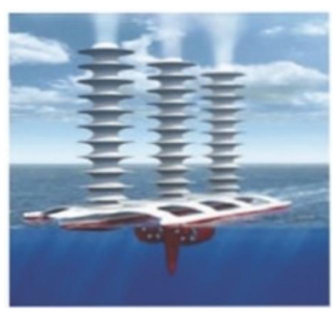
The AAGS report states that the *Nature Science* study "supports only one conclusion: focusing only on limiting emissions is a wasteful and futile strategy." Instead the report urges removal of restrictions on research into technologies for controlled climate cooling.

"There are scores of such technologies on drawing boards around the globe," said Dr. Williams. "Land-based filters could remove excess CO_2 from the air; high-altitude reflectors could be turned on and off to reduce solar heating; organic materials could be added to the ocean to speed up natural CO_2 absorption."

Developing these so-called geoengineering technologies, the AAGS report concludes, would not only be more effective than additional emission restrictions, but would also spare consumers and businesses from the heavy economic costs associated with the regulations necessary to reduce atmospheric CO_2 concentrations to 450 ppm or lower.

"Human beings have faced challenges from nature throughout history," Williams told reporters at a press conference. "We've never succumbed to those challenges – we've always overcome them with ingenuity."

"Consider today's high-yield agricultural techniques, the miracles of modern medicine, and our breathtaking feats of urban engineering," Williams stated. "Well, the time has come for us to innovate our way out of another jam."



Geoengineering response to climate change. AAGS report proposes "geoengineering" after study finds that without "measures to remove gases ready in the atmosphere or induce atmospheric cooling, existing CO_2 concentrations will cause irreversible environmental damage." Filters (left) could be placed in wilderness areas and that would soak up billions of tons of CO_2 from the atmosphere. Turbine-fitted vessels (right) could spray a mist to whiten clouds and make them more reflective of incoming sunlight. (Credit: AAGS Report, "Beating Climate Change: Creating New Technologies, Not Restricting Old Ones.")

A2.3 Scientific Article Excerpt

Excerpt from: "Irreversible climate change due to CO_2 emissions," *Nature Science,* Vol. 73, pp. 516-32 (2018):

Even if we could halt human carbon emissions today, the world would face risks of climate change for well over 1,000 years. The impact of CO_2 emissions persists longer than that of nuclear waste, the archetypical long-lived waste product. However, an immediate emissions halt is essentially impossible. Moreover, simple projections suggest that even with strenuous efforts to limit emissions, atmospheric concentrations will rise beyond 450 ppm, the level commonly thought to be the maximum safe upper limit.

If CO_2 is allowed to peak at 450-600 ppm, the results will include persistent decreases in dry-season rainfall comparable to the 1930s North American Dust Bowl in zones including southern Europe, northern Africa, southwestern North America, southern Africa and western Australia.

Such concentrations can also be expected to generate irreversible changes in the geography of the Earth because many coastal and island features would ultimately become submerged.

Attribution studies suggest that such a drying pattern is already occurring, particularly in the southwestern United States and Mediterranean basin. For the same reason, the physical climate changes that are due to CO_2 already in the atmosphere today are expected to be largely irreversible.

It is sometimes imagined that a choice can be made to quickly reduce emissions and thereby reverse any harm from climate change within a few years or decades. We have shown that this assumption is incorrect, because of the longevity of the atmospheric CO_2 perturbation and ocean warming. Irreversible climate changes due to CO_2 emissions have already taken place, and future carbon dioxide emissions would imply further irreversible effects on the planet.

Advances in modeling have led not only to improvements in complex Atmosphere-Ocean General Circulation Models (AOGCMs) for projecting 21st century climate, but also to the implementation of Earth System Models of Intermediate Complexity (EMICs) for millennial time scales. These two types of models have been used in this paper to show how peak carbon dioxide concentrations that can be expected in the 21st century are likely to lead to substantial and irreversible damage to the environment.

4 Catching Carbon with NETs: Case Studies in Elite Institutional Support

4.1 Background

If the threat posed by climate change presents a dauntingly complex policy domain rife with inherent challenges to ordinary processes of policymaking and implementation, as indeed it does, the domestic political resistance to addressing the threat only serves to exacerbate those challenges. Political resistance can be a significant cost factor in assessing policy costs and benefits (Richards 2000; Krutilla 2011), yet most scholarship on climate policy pays it little regard and focuses strongly on traditional metrics of policy analysis—notably the economic efficiency and/or scientific effectiveness of any given policy instrument or combination of instruments. Political viability—the prospect of a policy proposal actually overcoming this resistance to be enacted and implemented, given the interests motivating those who influence and direct the policymaking agenda—is all too often mentioned only in passing (Fullerton 2001) or not at all.

Climate policy options categorized as “geoengineering,” as described in Chapter One of this dissertation, have been observed to elicit less political resistance from the general public than others (Mercer, Keith and Sharp 2011; Pidgeon et al. 2012; Kahan et al. 2015). On the other hand, public opinion alone does not make policy, as work on economic inequality demonstrates (e.g., Gilens and Page 2014). The findings of Chapter Three suggest an even more daunting challenge, as it appears that while politically influential economic elites are comparably open to geoengineering, and indeed less resistant to climate policy overall than the general public, even those preferences may be dominated by partisan polarization and the ensuing resistance it generates.

However, obstacles to the political viability of any given policy option do not exist solely in the form of attitudes amongst individual voters, of any economic stratum. There is a rich literature on the influence of organized interest groups, policy entrepreneurs, and other institutional actors, operating in a middle ground between ordinary citizens and formal policymakers. Moreover, as with individual preferences, this influence is not equitably distributed. While past scholarship often posited a framework of majoritarian pluralism, a "polyarchy" in which a wide diversity of interests is represented, Gilens and colleagues (Gilens 2012; Gilens and Page 2014) among other recent scholars find stronger support for a system of what they call "biased pluralism," in which the interests of corporate, business, and professional groups exert a dominant influence outweighing that of public interest organizations.

Accordingly, this chapter of this dissertation investigates the revealed preferences of elite (business and industrial) organized interests, as demonstrated through support for real-world geoengineering research programs and policy initiatives. (While these elites do technically include some individuals, they still typically act through institutional structures, either as policy entrepreneurs—e.g., through foundations—or as investors—e.g., through venture capital firms.) The approach is mixed-method, gathering case studies of geoengineering projects demonstrating a broad range of underlying characteristics, and employing qualitative comparative analysis (QCA) to interpret the criteria that drive their support.

This study provides a natural complement to Chapter Three, focused on the individual attitudes of economic elites via a survey experiment, and makes meaningful contributions to the literature in its own right. It supplements the existing research on broad public attitudes toward geoengineering with findings on elite institutional attitudes—an element of political viability no less crucial than individual economic-elite attitudes, per the findings of Gilens and Page (2014) among others. It also adds to the existing literature by compiling a detailed set of examples of geoengineering research proposals and initiatives to date, including relevant variables that characterize and categorize those examples. In so doing, it can not only inform future research, but provide guidance to climate policy advocates on how to shape future geoengineering proposals in a way most likely to attract constructive support.

4.2 Research Question

Beyond individual attitudes, interest groups and other institutional actors also influence political viability, with the wealthiest and most business-oriented exerting the greatest influence on prospects for agenda-setting and policy enactment. To what extent do geoengineering-related initiatives garner support from economic elites, including institutional actors?

4.3 Review of Relevant Literature

Organized interest groups and other institutional actors seldom participate in opinion surveys, and indeed seldom take positions on completely hypothetical policy alternatives, focusing their attention instead on supporting or opposing initiatives with some credible chance of advancing in the policy arena. Fortunately, this does not mean only fully realized policy proposals: the literature reminds us that there is a spectrum of stages through which new innovations and initiatives develop, many of which may attract institutional attention and involvement. Many geoengineering prospects are situated among such developmental stages.

Grubb (2004), for instance, zeroes in on the role of technological innovation in GHG mitigation. He emphasizes that innovation cannot be taken for granted, but that it can be increased with a “push-pull” dynamic, with early publicly funded research and development (R&D) efforts enabling later market-driven investment, noting that costs decline dramatically as technology improves. Grubb identifies six developmental stages of effective technical innovation: basic research, technology-specific research, market demonstration, commercialization, market accumulation, and diffusion. These stages limn the range of possibilities for one criterion key to distinguishing case studies, as discussed below in the Methodology section.

Current scholarship reflects a broad consensus that geoengineering is worthy of further in-depth research, although this view is not universal or unqualified. For instance, Schneider (2008) reviews the state of the literature on geoengineering techniques over the preceding two decades; he concludes that anthropogenic climate change is itself effectively a form of (unplanned) geoengineering, and identifies an emerging consensus that comparably engineered countermeasures are at least worthy of coordinated R&D efforts. He further observes that notwithstanding extensive scientific modeling, when it comes to policy choices "values will dominate the trade-off: for example, risk aversion versus risk proneness or the precautionary principle for protecting nature versus the unfettered capacity of enterprising individuals, firms or nations to act to improve their economic conditions" (Schneider 2008, 3858).

Some have gone so far as to propose recommendations for governance regimes. For instance, Vaughan and Lenton (2011) find existing research (to that date) limited largely to theoretical concepts and computer models, with little experimental work (aside from a few notable exceptions involving afforestation, ocean fertilization, carbon capture and storage (CCS), and atmospheric carbon recapture). They note that field experiments are not always feasible, and emphasize that geoengineering should be seen as a supplement to mitigation efforts rather than a substitute. This is an important concern, as depending on the specific technologies under discussion—especially solar radiation management (SRM) as contrasted with carbon dioxide removal (CDR)—geoengineering efforts may only stave off the effects of climate change, without reducing the atmospheric GHG concentrations that cause those effects. In response, Vaughan and Lenton argue not only that a more ambitious research agenda is needed, but also for some kind of coordinated governance to provide oversight. In its absence, some geoengineering options (most notably stratospheric aerosols and ocean fertilization) could readily be implemented unilaterally by a single state or even a wealthy non-state actor, despite potential ethical and legal issues.

Reflecting similar concerns, Hahn et al. (2011) present an open letter from climate experts that offers a set of design guidelines for policies they deem "credible, easily monitored, and easily enforced." It is written in broad strokes, but echoes the stabilization wedge concept (Pacala and Socolow 2004; Socolow and Glaser 2009; Davis et al. 2013) in some ways—

pointing policymakers away from attempts at ambitious "comprehensive" policy solutions, especially in the international arena, and encouraging them instead to take a flexible approach and embrace "all realistic options." In this context, not unlike both Grubb and Schneider, Hahn and colleagues underscore the importance of scientific R&D and technological innovation, not just in renewable energy, but also in CCS and more novel forms of geoengineering. Alternately and more ambitiously, Dilling and Hauser (2013) propose a three-pronged framework for governance, focusing on (A) the direct physical risks of the technology being researched, (B) transparency and accountability in decision making, and (C) most abstractly, the social implications of the technology.

Others are more skeptical. Humphreys (2011) considers the challenges to coordinated governance of such technologies, including variations in comparative technological advantages and potentially differentiated obligations among states, and the possible role of CDR in emissions trading and carbon-offset schemes, and anticipates nearly intractable collective action problems comparable to those that have plagued conventional attempts to negotiate climate solutions under the UNFCCC framework. Similarly, Parson and Keith (2013) lament what they describe as an ongoing "deadlock" on geoengineering governance, and the way the lack of an agreed-upon oversight regime makes research riskier. They propose breaking this deadlock by drawing thresholds between small-, medium-, and large-scale experiments, with a moratorium on the last of these for the sake of risk aversion, but a more ambitious research initiative on the first.

Barrett (2014) argues that effective governance of *any* kind could be a challenge, at least in regard to SRM, precisely because (as Vaughan and Lenton (2011) observe) the technologies involved are both relatively inexpensive and highly scalable, and could be deployed unilaterally or by a "coalition of the willing," evading any particular governing jurisdiction. The best-case approach he posits is one analogous to the way global satellite navigation systems are governed: although the now-familiar GPS technology was developed and deployed by the U.S. and made freely available for use worldwide, other regimes, notably Russia, China, and the E.U., have developed comparable systems under their own control. The obvious incentives for interoperability, nevertheless, have led to a number of bilateral agreements as well as a forum for multilateral interaction, under U.N. auspices, for all countries capable of such systems. Long, Loy, and Morgan (2015) also offer a somewhat optimistic view, tinged with pragmatism, suggesting that it is infeasible to ban or deter research and development until a comprehensive governance regime is in place, and suggesting instead that governance can and will co-evolve alongside research, starting with projects at the smallest scale and lowest risk level.

More recently, some scholars are coming to the conclusion that geoengineering efforts are not only worthwhile but inescapably *necessary*, not least due to past failures at comprehensive mitigation efforts and projected limits on the efficacy of mitigation going forward. In its most recent comprehensive report, the Intergovernmental Panel on Climate Change (IPCC 2014) modeled over a thousand scenarios. Of these, only 116 successfully limit climate warming to no more than the 2°C threshold considered the scientific consensus for safety… and of those, 108 rely on reducing atmospheric GHG concentrations using technologies yet to be developed (Kolbert 2017). Reacting to this, MacCracken (2016) argues that despite governance challenges, the time has come to focus on both atmospheric and surface-based technologies that can reduce climate impacts on a regional scale, if not yet a multinational scale. Honegger and Reiner (2018) argue that in light of current high costs, financial incentives can and should be used to motivate “progressive industrialized countries” to take first steps to deploy “Negative Emissions Technologies” (NETs). (NET is a common alternate term for CDR, especially in more recent literature, because of these technologies' capacity to reduce atmospheric concentrations of GHGs, rather than just mitigate emissions.) Minx et al. (2018) agree that such technologies are only weakly incentivized to date, but argue that a broad portfolio of NETs would be invaluable for staying within either a 1.5°C or a 2°C climate warming goal. Where CDR/NET is concerned, Amador (2016) argues that obstacles (other than cost) may actually be minimal, as extant atmospheric CO_2 is quintessentially a non-rival good; no one benefits from keeping it in the air, and no industry lobby will be threatened by efforts to remove it.

Rayner (2014) takes note of contrarian scholars who oppose geoengineering R&D as a "slippery slope" on the grounds that the uncertainties and risks are too profound. Gardiner (2011), for instance, posits that even considering geoengineering options involves acknowledging a "moral failure of spectacular scope and import" (Gardiner 2011, 168), and hence that moving ahead with such options poses a classic moral hazard. Barrett and colleagues (Barrett 2014; Barrett et al. 2014) express similar concerns about moral hazard, arguing that SRM techniques in particular could be a seductive and even "addictive" distraction, offering seeming quick fixes that tempt decision makers away from more comprehensive mitigation or adaptation efforts. Rayner (2014) posits that he might agree if the situation were constrained only to all-or-nothing action, a choice of extremes—but as it is not (e.g., he emphasizes the asymmetries between SRM and CDR, noting the different ways they can complement other efforts), he adds his voice to the chorus that advocates reducing ignorance (and associated risk aversion rooted therein) through a well-designed program of research.

Similarly, Cusack et al. (2014) acknowledge the moral implications of geoengineering and agree that traditional emissions abatement strategies remain the most desirable policies, but also emphasize the importance of drawing informed distinctions, and offer several criteria for comparing and evaluating geoengineering techniques—concluding that many are low-risk and deserve immediate further research, while others (particularly SRM) pose more significant risks and, hence, ethical concerns.

In contrast on that point, Frumhoff and Stephens (2018) argue that SRM is also worth pursuing, and that despite both its known risks and the current low levels of public awareness, it can (and should) be researched in a way that promotes its scientific legitimacy by engaging multiple stakeholders in open discourse about the risks involved—including the competing risks of severe climate change, and the prospect that traditional approaches may be insufficient to contain those risks.

Merk et al. (2018) confront the moral hazard argument directly and empirically, using professional discourse and interviews to analyze expert opinion about both CDR and SRM, and conclude that experts do *not* indulge in moral hazard behavior, but instead retain policy preferences for mitigation as a first recourse, and demonstrate high awareness of not just the potential benefits but also the risks of geoengineering strategies. Exemplifying this awareness, an *ad hoc* group of experts (Rayner et al. 2009) had long since developed and promulgated what have come to be known as the "Oxford Principles," proposing five ethical guidelines for geoengineering research: that it be regulated as a public good, that decision-making involve public participation, that research be open and transparent, that impacts be assessed independently from feasibility, and that governance precede full-scale deployments. These principles were endorsed by the UK House of Commons' Select Committee on Science and Technology, and have provided a framework for later scholars (e.g., Corner, Pidgeon, and Parkhill 2012; Welch et al. 2012; Rayner et al. 2013).

Meanwhile, as this scholarship has developed, a number of public or quasi-public institutions have weighed in on the topic. The Government Accountability Office, in a pair of reports (GAO 2010a; 2010b), finds that the National Science Foundation (NSF), Department of Energy (DOE), NASA, and a few other federal agencies "have funded some research and small demonstration projects of certain technologies related to proposed geoengineering approaches; but these efforts have been limited, fragmented, and not coordinated as part of a federal geoengineering strategy" (GAO 2010a, 1). Specifically, the GAO finds that of about $4 billion of federal money invested in climate-related research in FY 2009-'10 (NRC 2015b), only $100.9 million was spent on projects potentially "relevant" to geoengineering, and most of that was focused on conventional mitigation research, with only $1.9 million focused directly on CDR or SRM—less than 0.05 percent of the total funds. In an in-depth follow-up report (GAO 2011), the GAO assesses CDR techniques according to a variety of criteria including "technology readiness level" (TRL), and finds none with a TRL above 3 (on a scale of 9), the highest being atmospheric carbon recapture. In that same report, however, it includes survey data indicating that 65 percent of the public would support increased geoengineering research, and about 45-50% would support spending federal money on that research. (It is tangentially noteworthy that a larger share (75 percent) support efforts at emissions reduction and/or increased reliance on solar and wind power as energy sources, but little policy headway has been made along those lines, for reasons that include the political resistance discussed earlier, exacerbated by the representational inequality and polarization detailed in Chapter One.)

Funding has been scant from the nonprofit sector as well. For example, a study on private philanthropy conducted by the Center for Carbon Removal, a nonprofit initiative of the Berkeley Energy and Climate Institute (Amador 2016), finds that less than 0.4 percent of climate-related philanthropy in the U.S. from 2008-2014 (a total of $5.3 million) was directly related to carbon removal (CDR) research.

The abovementioned GAO reports were components of a larger research project into the subject by the House Committee on Science and Technology, chaired at the time by Rep. Bart Gordon, in collaboration with a similar committee from the UK's House of Commons. The final report (House 2010) refers approvingly to the National Nanotechnology Initiative (NNI)—an executive-branch project from 2000, made statutory by Congress in 2003 and amended and reauthorized in 2010—as a model for a cutting-edge interagency research initiative with clear oversight. The Committee observes that like geoengineering, nanotechnology holds the promise of revolutionary advances to the public good, but also faces concerns about uncertain risks. The NNI is a multi-agency initiative that coordinates nanotech research, development, education, and training, and also interfaces with international consortia such as the OECD to address safety concerns. The Committee's report recommends an initiative along comparable lines for geoengineering research. However, the report's recommendation has never been realized.

The Congressional Research Service offers a similar overview (Bracmort and Lattanzio 2013), also noting nanotechnology research as an earlier model for successful governmental research oversight and coordination (as well as nuclear power and molecular biology). The report takes particular note of conflicted incentives for private investment, including long-term uncertainties about both technical feasibility and the potential for commercialization, and the lack of a price mechanism on carbon emissions, and recommends filling the gap with a coordinated publicly subsidized research initiative, accompanied by a clear oversight regime. However, the recommendations have never been realized.

The National Research Council of the National Academies of Sciences, with funding from the NSF, the U.S. intelligence community, and several federal agencies, has produced a pair of detailed reports on CDR and SRM respectively (NRC 2015a, 2015b). They recommend increased public investment in geoengineering research, focusing on CDR and small-scale field experiments in SRM (echoing Parson and Keith (2013)), along with construction of a clear oversight regime. However, the recommendation has not been realized.

Most recently, the U.S. Global Change Research Program (USGCRP), an executive-branch program of the Office of Science and Technology Policy that coordinates and integrates research efforts among 13 federal agencies, in its triennial report to Congress (USGCRP 2017), cites the NRC studies and notes that deliberate geoengineering may be a useful part of a portfolio of tools used to manage climate change, and emphasizes the need to understand both the possibilities and the limits of geoengineering, especially in light of the recognition (as in Vaughan and Lenton 2011) that other countries or the private sector may seek to use such tools to pursue climate interventions unilaterally. It emphasizes attention to the scale and scope of observations and modeling capabilities, in order to "define the smallest scale of [geoengineering] intervention experiments that would yield meaningful scientific understanding" (USCGRP 2017, 37) again echoing the logic of Parson and Keith (2013) and Long, Loy, and Morgan (2015). The steps it recommends, however, have not yet been realized.

In light of inadequate policy formation to date, then, it is instructive to examine the *ad hoc* geoengineering research initiatives that have nevertheless taken place.

4.4 Research Approach, Data, and Methodology

The goal of this study is to discern the climate policy attitudes of influential institutional actors—but of course, as noted, it is impractical to conduct an opinion survey of such actors. A different approach is called for, looking to other indicators, seeking revealed preferences in a real-world context. The methodologies employed by Baumgartner et al. (2009) to assess the effect of lobbying activities, and similarly by Gilens (2012) and Gilens and Page (2014) to test theories of Biased Pluralism, although they are not directly applicable, provide guidance and incorporate elements that should be roughly adaptable.

As part of their large-scale Advocacy and Public Policymaking project, Baumgartner and colleagues begin with a random sample of Washington interest groups, weighted by volume of lobbying activity, and then conduct interviews to identify 98 issues on which those groups are active (most of which are very low-salience). They then identify and measure several variables characterizing the groups, issues, and policy outcomes, to facilitate quantitative modeling. They construct a composite index of group resources, comprising ten factors, and determine that comparative advantage on the resource index is (weakly) correlated with policy success. They also note a strong correlation (r=.73) between the resource index and the number of advocates on a given side of an issue from *Forbes* magazine's "Power 25" list, an annual ranking of the most powerful lobbying organizations in Washington. However, they caution against inferring that lobbying is a direct determinant of policy change, not least because policymaking involves a substantial status quo bias: commenting on the successful track record of the banking industry, for instance, they emphasize that "the ability of some groups in society to mobilize more efficiency, and therefore to lobby with a louder and more effective voice in politics, is *already reflected in the status quo policy*." (Baumgartner et al. 2009, 250; emphasis in original.) Keeping a new policy option *off* the political agenda through strategic opposition, in other words, also emerges as an exercise of influence, and often an easier one.

Gilens and Page work with a wide-ranging large-N data set of 1,779 relatively high-salience policy proposals spanning 22 years, and are therefore also able to utilize a predominantly quantitative approach. In conjunction with this they springboard from the findings of Baumgartner and colleagues by compiling a list of interest groups appearing on the “Power 25” ranking over a span of years—including groups they categorize as both elite (business-oriented) groups and (in a few instances) mass-based (i.e., public interest)—supplemented by the ten industries with the highest lobbying expenditures not already represented on the list, as they lobby directly rather than through trade organizations. Gilens and Page code each group/industry for its positions (if any) on each policy proposal in the data set, calculate an index of Net Interest Group Alignments, and analyze the impact of the index measure on each policy outcome. Importantly, they find almost no relationship between interest group alignments and average citizen preferences, but a strongly significant relationship between interest group alignments and policy outcomes—and moreover, the magnitude of the effect for elite groups is almost twice that for mass groups.

The work of both Baumgartner et al. and Gilens et al. provides models to emulate by way of sources, as it makes exemplary use of public-domain information archived online, including organizational statements, government agency activities, legislative bills and statements, committee hearings, and news stories. However, there are also some notable distinctions. Baumgartner et al. focus on traditional lobbying and hence use access to Congress as a criterion for influence; Gilens and Page take a different approach to identifying influential actors, focused primarily on the largest players (as on the *Forbes* list) but emphasizing a distinction between (business oriented) elites and (public interest) mass groups.

The project at hand, although it strives to reflect similar underlying political dynamics, is of course focused much more narrowly than either of these—on a single salient policy domain and a subset of options within it—and certainly isn't intended to occupy a large team of researchers over a period of years. A conventional large-N quantitative-modeling approach would be neither appropriate nor feasible. Accordingly, it becomes necessary to adapt the methodology to employ a case-study approach.

4.4.1 Qualitative Comparative Analysis (QCA)

In the context at hand, where the limited number of cases available makes a large-N approach unrealistic, it seems sensible to invert the analytical approach taken by Gilens and Page, and work bottom-up rather than top-down. The case-study orientation of this research, the small-N data set those cases comprise, the strongly theory-driven nature of the study (with the choice of variables influenced by Gilens and Page's findings concerning biased pluralism), and the defining characteristics of many of the cases, all recommend in favor of qualitative comparative analysis (QCA) as the method of choice.

First developed by political scientist Charles Ragin (Ragin 1987), QCA represents a bridge between qualitative and quantitative methodology, involving both within-case and cross-case analysis. It focuses on first identifying and then minimizing the combinations of underlying conditions contributing to various case-based outcomes, using set theory (based on relationships of necessity and sufficiency) and Boolean logic. Combinations of conditions can be evaluated in terms of both coverage (the percentage of case outcomes they explain) and consistency (the frequency with which a combination is associated with a given case outcome). In other words, coverage is a measure of the extent to which given (combinations of) conditions are necessary, while consistency is a measure of the degree to which they are sufficient.

This is particularly useful for analyses involving a modest number of cases, in which variation in some underlying indicator is less meaningful in precise terms than in how it signifies membership in a set. While QCA was originally developed only for dichotomous variables, it has subsequently been expanded to accommodate multiple-value conditions (mvQCA) and "fuzzy sets" with partial degrees of set membership (fsQCA), allowing even categorical conditions to be weighted by matters of degree. A fuzzy set is one in which membership depends on conceptual boundaries, not precise empirical measurement; for instance, the distinction between a person being bald, mostly bald, partially bald, or non-bald does not depend on knowing the exact number of hairs on the person's head (Schneider & Wagemann 2012).

Discussing the example of economic development by country, Ragin (2008) points out that any given selection of countries will demonstrate wide variation in an indicator such as gross domestic product (GDP) per capita, and a traditional statistical regression approach will treat the entire range of variation as equally relevant, and do likewise for whatever central tendency it indicates. That can be misleading, however, when what is of more interest to the researcher is membership in the set of "highly developed countries," for which *clusters* of variation in GDP per capita represent categorical degrees of membership grounded in theory (e.g., "mostly but not fully in the target set")… while the central tendency may not represent a meaningful qualitative anchor, and fine degrees of variation (especially near the extremes) may not be relevant at all. Measures like the mean are mere properties of the data (and subject to being skewed by outliers), and hence devoid of substantive conceptual meaning.

In this approach, it is crucial that values for each indicator condition be calibrated according to theoretically grounded external knowledge, linking that knowledge to the empirical analysis. As Ragin (2008, 83) puts it, "After all, it is more common for theoretical discourse to be organized around designated sets of cases (e.g., developed countries) than it is for it to be organized around generic variables (e.g., level of economic development)." Traditional statistical methods rely on correlational analysis which is insensitive to these calibrations, and incapable of assessing set-theoretic relationships. (E.g., it assumes measures vary symmetrically between independent and dependent variables, and cannot identify *asymmetric* relations, such as a combination of conditions that is sufficient but not necessary (or vice-versa) for a specific outcome.) If the researcher is interested in linear additive effects of single independent variables, such methods can be powerful and appropriate, but if the goal is to identify complex causal relationships among specific cases, fsQCA is a more suitable tool. Beyond asymmetry, it also allows for *equifinality* (different, mutually non-exclusive explanations of a phenomenon) and *conjunctional causation* (where the effects of a single condition unfold only in combination with others) (Schneider and Wagemann 2012).

Throughout this study, I have endeavored to follow the best practices for fsQCA summarized by Schneider and Wagemann (2010), entailing twenty-six guidelines applying to the full process, from data assembly to analysis to presentation of results.

The first step of the QCA in this study was to identify specific geoengineering cases to include in the data set. As noted above, while there has been much scholarly discussion of geoengineering in recent years, there have been relatively few specific policy initiatives to date. Still, it was feasible to identify several dozen notable examples of relevant (usually small-scale or early-stage) proposals and initiatives, with (variously) governmental, interest-group, and private-sector financial support. The scope conditions for the universe of relevant cases includes all R&D initiatives conducted or reported in the English language that were active as of the data gathering process (2019) or had been active within the previous ten years, that involved any of the geoeningineering “areas of focus” described below under Conditions, and that were not strictly academic exercises in modeling or risk assessment. Selected examples of these cases are discussed in the Case Studies section below.

For all cases identified as relevant, key defining variables (“conditions”) were then coded and calibrated for analysis in “truth tables” reflecting all logically possible combinations. The coding criteria, chosen based on the geoengineering literature, are described in greater detail below. The fsQCA 2.0 software, designed by Ragin, uses the Quine-McCluskey algorithm (a minimization procedure using Boolean logic) to parse the truth tables, identify necessary and/or sufficient conditions and combinations thereof, resolve contradictions, and report results.

4.4.2 Conditions

There are several types of relevant criteria (“conditions”) assessed for each case study and coded into the QCA truth tables. They include the following:

4.4.2.1 Area of Focus

The case studies analyzed in this study, and exemplified by those described later in this chapter, reflect different areas of focus under the broad umbrella of geoengineering, subdivided into techniques focused on post-emission *carbon dioxide removal* (CDR, more broadly analogous to mitigation, as it targets causes) and those focused on *solar radiation management* (SRM, more analogous to adaptation, as it targets effects) (Royal Society 2009). Within CDR, the focal areas for specific case studies are widely varied, and include carbon conversion technologies shared with carbon capture and sequestration (CCS), a more conventional mitigation technique. SRM likewise encompasses a variety of distinct technologies. There are also broad-based research programs that divide their focus among multiple technologies.

Carbon capture and sequestration (CCS) is not strictly speaking a geoengineering technology *per se*, unlike carbon dioxide removal (CDR). It typically involves capturing CO_2 from stationary sources at the point of emission, and can do this from either fossil fuel- or biomass-based energy generation sources, so it doesn't necessarily result in a net reduction of atmospheric CO_2, although as Amador (2016) succinctly explains, it can do so when paired with biomass. The captured CO_2 is typically earmarked for geological (i.e., underground) sequestration, and is sometimes used for "enhanced oil recovery" (EOR), whereby CO_2 is injected into an oil reservoir to help with extraction, so again, the involvement of fossil fuels in the overall system means the total CO_2 reduction may not represent a net negative.

However, certain cutting-edge CCS research initiatives do show significant areas of overlap with geoengineering, especially insofar as some of them involve novel approaches to the "sequestration" part of the acronym, involving efforts to convert captured carbon for other industrial or commercial purposes. This functionality is every bit as useful for direct air capture (DAC) of CO_2 from the atmosphere, one of the most prominent categories of CDR. Some of these conversion initiatives are accordingly relevant to this research, albeit tangentially.

More precisely, CDR—also often referred to as Negative Emissions Technology (NET), as noted earlier—refers to any of a number of technological processes for recapturing CO_2 (or other GHGs) from the atmosphere *after* the point of emission. Unlike traditional CCS, therefore, which is limited to stationary sources, it can also capture carbon from mobile sources such as motor vehicles, and holds the potential to reduce net atmospheric GHGs below present levels, independent of ongoing emission rates.

Among the different technologies under the rubric of CDR, from the least to the most "pure" in terms of their focus, are production of biochar, a soil additive created by the pyrolysis (high-temperature heating) of biomass, or of algae, which can be used for various purposes including agricultural feedstock (both of which overlap frequently with CCS initiatives); ocean fertilization, which involves either adding nutrients such as iron to the upper ocean to stimulate the growth of phytoplankton (which absorbs CO_2 through photosynthesis, although it can also be used as a means of aquaculture), or upwelling of deep ocean waters that are already nutrient-rich; enhanced weathering, which involves dissolving silicates or other minerals on land or water to increase natural CO_2 absorption (and, incidentally, counter ocean acidification); and finally direct air capture (DAC), which recaptures ambient CO_2 via strategically deployed "carbon sponges" or "artificial trees" using any of several types of chemical processes. Minx et al. (2018) and Fuss et al. (2018), among many others, provide an elegant consensus overview and taxonomy of these techniques.

(Afforestation and reforestation can also be considered methods of CDR, as they increase natural carbon sinks. They are not included in this study, however, as the technology involved is already well understood (Minx et al. 2018), and indeed they have long been considered to fall among conventional mitigation techniques (Heyward 2013). The challenges involved are not scientific or technological, nor for that matter primarily political, but rather economic, given the land-use competition for purposes of agriculture and other forms of development.)

Meanwhile, where SRM is concerned, the focal areas for specific case studies include stratospheric and tropospheric aerosols, cloud seeding, and oceanic micro-bubbles. While their means differ, all of these approaches share an equal focus on reducing the albedo (i.e., reflectivity) of the Earth system, thereby reducing the radiative forcing effect of solar radiation that is otherwise increased (firstly) by atmospheric GHGs and (secondly) by feedback loop effects such as arctic melting. SRM is substantially different from CDR, not merely in terms of the technologies involved but also in terms of the costs involved (typically lower), the time frames required (typically shorter), and the potential risks (typically higher). Nevertheless, CDR and SRM are conventionally united under the larger rubric of "geoengineering," as what they share is direct intervention into the climate system (Minx et al. 2018).

For purposes of QCA calibration, different technologies' degree of membership in the set of "pure" CDR methods varies: on a scale of 0-1, CCS is coded as 0.2 ("mostly out"), algae and biochar are coded as 0.4 ("more out than in"), ocean fertilization as 0.6 ("more in than out"), upwelling and enhanced weathering as 0.8 ("mostly in"), and DAC as 1.0 ("fully in"). All different SRM technologies are coded as 1.0, as they have no alternative purposes or intended effects.

4.4.2.2 Economic Elites

As part of the process of identifying relevant cases and developing a consistent coding framework, a key step of the QCA is to investigate the organizations and institutions these cases have relied upon for advocacy, expertise, and most importantly funding. This data has been gathered using resources including (for private companies) CrunchBase, the D&B Global Business Browser, Mergent Intellect and Mergent Online (by FTSE Russell), PrivCo, the Reference USA business database, and S&P Capital IQ, and (for nonprofit entities) GuideStar and the Foundation Center.

The dependent variable, *aka* the "outcome" in QCA nomenclature, is degree of membership in the set of cases with strong support from entities identifiable as economic "elites." I accordingly code the actors involved according to the criteria employed by Gilens and Page

(2014)—as either mass-based or elite. It makes sense to take a fairly organic approach to this, identifying leading figures and institutional entities among those who have taken a hand on behalf of (or against) these projects; as the cases include public/private and entirely private ventures as well, recognized lobbying clout may sometimes signify relative status, but is not the most important criterion. Mass-based actors include public-interest-oriented interest groups (nonprofits, NGOs, foundations) as well as public-sector (governmental) entities. Elite actors, with disproportionate economic and political influence, include groups oriented around business, industrial, or financial interests, as well as wealthy private individuals operating as policy entrepreneurs. In instances involving public-private partnerships, the status is weighted by relative degree of involvement. Specific examples are discussed in the Case Studies and Analysis sections that follow.

4.4.2.3 Degree of Support

For calibration purposes, each case's degree of membership in the set with "strong elite support" is measured by an indexed metric involving two sub-factors. First is the degree of economic eliteness of a case's primary supporters: the public sector is coded as 0.0 (as government agencies are constrained by the need to do as directed by policymakers, and have limited ability to exert influence over them); nonprofits (except those founded for the specific purpose of promoting geoengineering) are coded as 0.2, as they may attempt to exert political influence, but it is muted by their public-interest orientation; partnerships between nonprofits and private entities are coded as 0.4; public-private partnerships are coded as 0.6; and private entities (with the exception of universities, which are grouped with nonprofits) are coded as 1.0, as they have the most reliable influence on political feasibility.

Second is the extent of support exhibited by the case's stakeholders, which is based on the conceptual framework utilized by Gilens and Page, considering "both the magnitude of the impact of the policy change on the group or industry in question [i.e., depth] and also the extent to which the breadth of individual members of the group or industry would be affected [i.e., breadth]" (Gilens 2012, Supplementary Materials, 3–Interest Group Alignment Coding). If success of the initiative in a given case would impact stakeholders in a way that was substantially *both* broad and deep, Gilens and Page termed it "strong" (coded here as 1.0); if the impact would be either broad or deep, they termed it "somewhat" (coded here as 0.6); if it was neither, they termed it not favorable (coded here as 0.2).

The product of these two factors is an indexed measure of the outcome variable, "strong elite support," that itself ranges from 0 to 1, with 0.95 counting as full inclusion in the set, 0.05 counting as full exclusion, and 0.5 as the midpoint.

4.4.2.4 Developmental Stage

Grubb (2004) attempts to debunk the "false dichotomy" between "push" and "pull" theories about innovation in climate mitigation technologies, and in the process lays out a useful incremental taxonomy of developmental stages for such technologies that is easily and logically extensible to the geoengineering cases at hand. He defines these stages as:

1. *basic research and development*
2. *technology-specific* research, development, and demonstration
3. *market demonstration* to potential real-world purchasers and users
4. *commercialization*, involving adoption by established firms or newly created firms
5. *market accumulation*, in which use of the technology expands in scale
6. and *diffusion* to large-scale usage.

Each case study is coded according to these states. For purposes of QCA calibration, these stages are then translated to degrees of membership in the set of "fully developed geoengineering policy options," with stage one = 0.2, stage two = 0.4, stage three = 0.6, stage four = 0.8, and stages five and six both = 1.0 (a level not yet achieved by any case study in this data set).

4.4.2.5 Scope of Enterprise

The parameters of each case study are analyzed according to understandings gleaned from the literature, and the scope of the project is categorized as either non-state (for the smallest ventures), subnational (e.g., U.S. states and Canadian provinces), national, or multinational. These categories are calibrated for "degree of membership in the set of global-scale solutions" respectively as 0.2, 0.6, 0.8, and 1.0.

4.4.2.6 Program Origin

Each case study has its origins as either a public project (launched by some branch of government, or a public university), a nonprofit project (launched by a private university or an existing nonprofit organization), a public-private partnership, or a fully private enterprise (also including newly-created special-purpose nonprofits). These categories are calibrated for "degree of membership in the set of private-sector initiatives" respectively as 0.0, 0.2, 0.6, and 1.0.

4.4.2.7 Locus of Operations

Insofar as this research focuses on political feasibility within the United States, it reflects an understanding widespread in the literature that projects located within this country are by far the most salient for policymakers in this country. Each case study under examination has its operations focused primarily on foreign soil, in partnership between U.S. and foreign parties, or entirely in the U.S. These conditions are calibrated for "degree of membership in the set of domestic U.S. operations" respectively as 0.2, 0.6, and 1.0.

4.4.2.8 Opposition

Interestingly, notwithstanding the scholarly concern over risks, there is little organized opposition to geoengineering. The only substantial entity or initiative staking out a clearly opposed position is Geoengineering Monitor, a nonprofit organization that runs a web site (geoengineeringmonitor.org) dedicated to opposing all forms of geoengineering, on the basis of four expressed reasons: the site contends that it doesn't work, that it would inevitably be weaponized, that it detracts from real solutions (i.e., the moral hazard argument), and that it threatens human rights and biodiversity.

Geoengineering Monitor is a joint project of the ETC Group and Biofuelwatch. The ETC Group (*aka* the Action Group on Erosion, Technology, and Concentration) is a Canadian nonprofit that focuses on socioeconomic, ecological, and governance issues surrounding emerging technologies, especially in the developing world. Its most recent financial statement shows that its total revenue for FY 2017 was only $813,000, of which slightly more than half was provided by (and spent on) a variety of small projects. This was supplemented by grant funding, the largest single portion of which was slightly over $30,000 from the Heinrich Boell Foundation, a German NGO with close ties to the German Green Party. Biofeulwatch is a UK-based NGO dedicated to opposing all forms of biofuels. It does not have financial statements available, but its web site reports funding from a short list of philanthropic organizations, including the Boell Foundation.

In sum, Geoengineering Monitor is a project with sparse funding and sparser activities. It does not appear to engage in lobbying or activism. Its main avenue of influence is the web site itself, which offers a small assortment of publications and reports, as well as an impressive database and map of the projects and programs it opposes. This database is global in scope but also remarkably indiscriminate, as along with indisputably genuine geoengineering projects it also includes purely academic research and modeling efforts, private ventures that are long defunct, and initiatives related to CCS and other technologies that are related only marginally (or not at all) to geoengineering. Moreover, as its opposition is so indiscriminate, even if it were significant it would present a constant factor with equal impact on any and all case studies worth investigating. Accordingly, it is not treated as a meaningful factor in this research.

Otherwise, the most prominent incident of organized opposition to field research in geoengineering came in response to the UK-based SPICE Project (Stratospheric Particle Injection for Climate Engineering) in 2011. SPICE is a joint project of scientists from Oxford, Cambridge, Edinburgh, and Bristol Universities, one component of which had involved mounting an experiment intended to test the atmospheric effects of particle injection via a high-altitude balloon. A petition campaign was mounted by the ETC Group and a small group of allies, after which the UK's Engineering and Physical Science Research Council (EPSRC), one of the sponsors of the project, put the experiment on indefinite hold (Ruz 2011).

Beyond that single incident, I have uncovered no organized opposition specifically targeting any project qualified for inclusion as a case study in this research.

4.4.2.9 Exposure to Institutional Constraints

While organized opposition *per se* does not provide any counterweight to organized support of geoengineering (elite or otherwise), there are institutional constraints that can impose limits on certain kinds of initiatives. As the world's oceans are a longstanding subject of international law, they are unsurprisingly the main domain in which these constraints have arisen.

Specifically, the UN Convention on Biological Diversity (CBD) called in 2008 for a halt on ocean fertilization activities, except on a small scale. In 2010 the CBD acted more broadly, inviting parties to the Convention to "consider" a nonbinding moratorium on geoengineering activities "until there is an adequate scientific basis" to justify them, except for small studies conducted in controlled settings (Tollefson 2010; Bodansky 2011). Note, however, that the U.S. is not a party to the CBD.

Similarly, in 2008 the London Convention and Protocol, which regulates dumping of waste at sea, adopted a resolution urging "utmost caution" about ocean fertilization activities. Although this is also nonbinding and includes caveats, both it and the CBD's efforts have been leveraged as rhetorical ammunition against some ocean-based geoengineering experiments. Some analysts have also suggested that the 1987 Montreal Protocol on the ozone layer may pose an obstacle to stratospheric SRM experiments, although this proposition has not been tested (Bodansky 2011).

On the whole, however, while scholars and public officials have issued many calls for various governance regimes to oversee geoengineering research, it remains substantially unregulated. For purposes of QCA calibration of "membership in the set of cases facing institutional constraints," projects involving SRM via stratospheric aerosols have been coded 0.2 (or 0.4 if, like SPICE, they have faced substantial opposition), while projects involving CDR via ocean fertilization are coded 0.8.

4.5 Case Studies

In the distinctive policy subdomain of climate-related geoengineering projects, one would be hard-pressed not to detect a pattern among the case studies available for examination: typically small and isolated projects, often accompanying proposals for significant public research initiatives, but with no action from policymakers following up on those proposals. Nonetheless, a number of research projects have been launched in recent years without waiting for public-sector guidance or support. Overall, there are 53 cases that I identified, coded, and calibrated for QCA. The full table of cases is found in the Appendix. This section discusses a selection of noteworthy examples, arranged by (and chosen to represent) different areas of substantive technological focus. Table 4.1 offers a concise recap of the variety of technologies involved.

The cases identified, and the examples discussed, also represent a range of other defining criteria, including developmental stage, geographic scope, program origin, location, and others, as detailed under Conditions above.

Table 4.1. Geoengineering Variations Among Cases

Type	Subtype	Description
CDR (Carbon Dioxide Removal)	CCS (Carbon Capture & Sequestration)*	Captures CO_2 at the point of emission, in various forms suitable either for storage or for commercial usage. **Not* a form of CDR, strictly speaking, but often a complementary or transferable technology.
	Biochar production	Created by pyrolisis of biomass. Can be used as a soil additive. Often overlaps with CCS projects.
	Algae production	Algae consume CO_2. Can be used as agricultural feedstock or fuel. Often overlaps with CCS projects.
*The following subtypes of CDR are also frequently referred to as **NET** (Negative Emissions Technologies):*	Ocean fertilization	Adding nutrients such as iron increases CO_2-absorbing phytoplankton.
	Ocean upwelling	Brings deep nutrient-rich waters to the surface.
	Enhanced weathering	Dissolving minerals on land or water to increase natural CO_2 absorption.
	DAC (Direct Air Capture)	Uses chemical processes to recapture previously emitted CO_2 from the atmosphere.
SRM (Solar Radiation Management)	Micro-bubbles	Increases albedo by creating tiny bubbles on surface water by various means (ships' wakes, etc.)
	Cloud seeding	Increases albedo by increasing cloud cover.
	Stratospheric or tropospheric aerosols	Increases albedo by dispersing reflective compounds in upper atmosphere.

4.5.1 Carbon Capture and Sequestration (CCS)

As noted above, CCS is not intrinsically a geoengineering technique, and most research projects and initiatives related to it are not relevant to the research at hand. However, certain innovative techniques for carbon-neutral "recycling" of captured CO_2 into synthetic fuels, chemicals, polymers, or other materials or products, can provide a useful business-case "stepping stone” leading the way to more dedicated CDR activities (Amador 2016). In this context, a small selection of CCS cases stand out as relevant.

4.5.1.1 Case: Carbon XPRIZE

The XPrize Foundation, launched in 1995, is a nonprofit foundation organized around developing new technologies through incentivized competitions. It is designed to cross national, disciplinary, and industrial boundaries. The first XPrize was a $10 million prize for suborbital spaceflight, and more than a dozen contests have followed, with diverse goals ranging from medical diagnostic devices to clean water generation to educational technologies.

Of relevance here is the Carbon XPrize, a five-year contest launched in September 2015, focused on technologies to convert CO_2 into marketable products, as a means of mitigating climate change (XPrize Foundation 2018). The $20 million prize purse will go to the conversion technology producing the greatest value, as determined by (A) the amount of CO_2 it converts, and (B) the net value of the converted product(s), incorporating economic value, market size, and environmental impact, as judged by a panel of experts.

The Carbon XPrize is perhaps the most noteworthy example in this category, as it has incentivized research by a wide range of project teams. Out of 27 semifinalists chosen in 2016 based on written proposals, ten finalist research teams were selected in April 2018, with conversion outputs ranging from bioplastics to graphitic nanoparticles to concrete alternatives and more. Each finalist won an equal share of a $5 million “milestone” prize. Although the finalists are an international assortment hailing variously from the U.S., Canada, China, India, and Scotland, they are conducting their final-stage research at Integrated Test Centers in North America, with five teams competing at a Center located at a coal-fired power plant in Gillette, Wyoming, and five competing at a Center located at a natural-gas-fired power plant in Alberta, Canada (Alberta 2017). The winner will be announced in Fall 2020.

The XPrize Foundation recruits different sponsors for its various contests. For the Carbon XPrize, there are two sponsors, both corporate. One is NRG Energy, a power generator and retailer that is the corporate parent of Reliant Energy, with operations in Texas and New Jersey; in 2009 NRG started investing in clean energy research, with the announced goal of reducing its carbon emissions 50 percent by 2030 (Cardwell 2014). The other is COSIA (Canada's Oil Sands Innovation Alliance), an industrial association composed of ten companies that collectively account for over 90 percent of the oil sands production in Canada, with a shared charter to improve performance in four environmental areas, one of which is greenhouse gases (COSIA 2018).

4.5.1.2 Case: Alberta Carbon Conversion Technology Centre

The Alberta Carbon Conversion Technology Centre (ACCTC) was established in Alberta, Canada, in 2017, as a publicly funded test facility for innovative CO_2 capture and conversion technologies. The Centre's primary initial purpose is to provide a home to the Alberta-based finalists for the Carbon XPrize (discussed above). It is owned and operated by InnoTech Alberta, a government corporation financed by the Ministry of Economic Development and Trade. ACCTC received CA$20 million in startup funding, with sourcing evenly divided between the provincial and federal governments (Alberta 2017). As Alberta is well-known as a center of crude oil production from tar sands, some might dismiss this investment as a form of "greenwashing," but regardless of the underlying political motivations, it is more than symbolic, and has produced significant scientific results thus far.

4.5.1.3 Case: Arizona Public Service Company

In 2009, the Arizona Public Service Company, a private corporation that is the largest public utility in Arizona, received a $70.5 million grant from the U.S. Department of Energy for a project designed to use CO_2 from its coal-fired power plants to feed algae that could be developed into biofuels (John 2009). The company also sought part of a $100 million pool of DOE funds earmarked specifically for experimental CCS technologies. Like many other algae biofuel projects, this one was cancelled when its technology proved not to be efficient at a commercial scale (Wesoff 2017).

4.5.2 Carbon Dioxide Removal

CDR, as discussed above, is an umbrella terms that describes a portfolio of different technologies. The most focused and ambitious of these involve direct air capture. DAC is at the forefront of current discourse about "negative emissions technologies" (NET), and is the focus of startup firms such as Carbon Engineering (detailed below), Global Thermostat (founded in 2010), and the Swiss firm ClimeWorks AG (founded in 2009), all of which describe their technologies as market-ready or close to it, as well as other cases included in the data set, and think-tanks such as the Center for Carbon Removal (Kolbert 2017; Peters 2017). Other ventures are also exploring related technologies such as biochar production, ocean fertilization, and enhanced weathering.

Noteworthy projects exploring CDR options include the following:

4.5.2.1 Case: Carbon Engineering

Carbon Engineering is one of the leading private companies in the emerging field of DAC technology. Founded in 2009 by physicist Dr. David Keith (then of Carnegie Mellon and the University of Calgary, now of Harvard), with investments from Microsoft billionaire Bill Gates and Canadian oil sands billionaire N. Murray Edwards (Vidal 2018), the company set up its first pilot DAC system in 2015.

It conducted a new round of private financing in 2016 (McCullough 2016), and in mid-2018 announced that results to date demonstrate the ability to capture CO_2 for as little as $94 per ton (Service 2018; Keith et al. 2018). It has launched plans to validate the scalability of the technology to commercial levels, aiming at large-scale deployment by 2021 (Carbon Engineering 2018). The company also reports that it has led projects funded by various American and Canadian government agencies, including the U.S. Department of Energy. CEO Adrian Corless anticipates that success in this emerging domain could mean "trillion-dollar markets" (Kolbert 2017).

4.5.2.2 Case: Cool Planet

Cool Planet Energy Systems is a private company founded in 2009. Originally focused on converting biomass to renewable fuel, the firm faced challenges in that market as oil prices fell in recent years, and starting in 2016 shifted its emphasis to biochar production, which it found easier to commercialize (Vinluan 2017). The company conducted more than 70 field trials in its first year of biochar testing, and has aimed strongly at the agricultural market. In 13 successive rounds of funding since its founding, the company has raised a cumulative $261 million of venture capital, from investment firms and familiar corporate names such as BP, UBS, Conoco Phillips, and Google Ventures, as well as individual investment from Mexican retail billionaire Augustín Coppel, who now holds a seat on the company's board (PrivCo 2018).

4.5.2.3 Case: Ocean Nourishment Corporation

Many ocean fertilization efforts have been stymied in recent years, largely due to the institutional constraints described above. Several firms founded for this purpose have become defunct, even prominent ventures such as Climos, founded in 2006, for which notable technology entrepreneur Elon Musk was a founding investor. However, some remain at least nominally active. Among these is Ocean Nourishment Corporation, a private Australian corporation founded in 2004, which holds three patents pertaining to oceanic carbon sequestration. The company reports that it continues to seek suitable experimental sites, in collaboration with local populations and governments, but acknowledges that commercial implementation will await further research to satisfy regulatory concerns.

4.5.2.4 Case: Leverhulme Centre for Climate Change Mitigation

The Leverlhulme Centre for Climate Change Mitigation (LC3M) was established in 2015 at the University of Sheffield through a 10-year, £10 million grant from the Leverhulme Trust, a UK charitable foundation. It has a nine-member International Advisory Board composed primarily of scholars, including Dr. Ken Caldeira of the Carnegie Institution and Dr. James Hansen of Columbia University. It supports four multidisciplinary research themes, all of which involve aspects of enhanced weathering as a means of CO_2 removal: Earth Systems Modeling, Fundamental Crop Weathering Science, Applied Weathering Science, and Sustainability & Society. The LC3M is currently conducting applied weathering trials in three locations around the world: Illinois, Australia, and Borneo (Leverhulme 2018).

4.5.3 Solar Radiation Management

SRM, as discussed above, comprises a suite of technologies that together are considered to be less expensive and faster-acting than CDR, but also to pose greater risks of unanticipated consequences. Noteworthy projects exploring SRM options include the following:

4.5.3.1 Case: Academy of Finland

The Academy of Finland's Research Programme on Climate Change (FICCA), roughly the Finnish equivalent to the NSF, together with the Academy's Centre of Excellence Programme and the Maj & Tor Nessling Foundation (an environmental nonprofit), funded a study at the University of Eastern Finland focused on modeling SRM via the use of atmospheric aerosols in the stratosphere and troposphere. It found that these methods would successfully cool the surface (and that global airline and shipping exhaust could be harnessed for this purpose), but not at a level sufficient to counteract the overall warming effect of current levels of GHG emissions; hence, they would only be useful as a stopgap harm-reduction measure (Laakso et al. 2016).

4.5.3.2 Case: Keith Group

The Keith Group is a team of researchers at Harvard University, led by Dr. David Keith, focusing on SRM research. While Dr. Keith is a founder of the CDR firm Carbon Engineering, discussed above, and remains its Executive Chairman, he strongly opposes commercial development of SRM technologies, instead favoring further academic research into its potential risks and rewards. In particular, the Keith Group is heavily involved in Harvard's Solar Geoengineering Research Program, a broader interdisciplinary initiative (Keith Group 2018). Its current projects also include the Stratospheric Controlled Perturbation Experiment (SCoPEx), using a propelled high-altitude balloon to test stratospheric aerosols (SCoPeX 2018).

Since its founding in 2011, the Keith Group has received funding from a variety of public and private sources, including the U.S. National Science Foundation (NSF) and Canada's Natural Sciences Engineering and Research Council (NSERC), multiple internal Harvard grants, and a series of gifts from Bill Gates via FICER (described below).

4.5.3.3 Case: Marine Cloud Brightening Project

The Marine Cloud Brightening Project (MCBP) is a multi-institutional research collaborative housed at the University of Washington. Founded in 2006 with a $300,000 grant from FICER (discussed below), to date its collaborators have produced 16 papers studying the prospects for achieving global cooling by increasing the reflectivity of clouds, a concept first envisioned in 1990 by British physicist John Latham (Latham et al. 2012). It hopes to do this by developing spray technology that can generate microscopic seawater particles and inject them into low-lying clouds. It conducted its first field experiments in 2015 (Krieger 2015).

4.5.3.4 Case: GeoMIP

The Geoengineering Model Intercomparison Project (GeoMIP) seeks consensus among competing climate models for various scenarios incorporating SRM. (It specifically does not address CDR, for which a similar role is performed by a separate project dubbed CDR-MIP.) It is jointly led by Dr. Alan Robock of Rutgers University and Dr. Ben Kravitz of the Pacific Northwest National Laboratory (an arm of the Department of Energy), and receives funding from both, as well as from the National Science Foundation under grants GEO-1240507 (a cooperative agreement which also funds SCRiM, below, on which Robock is a co-PI) (NSF 2012b) and AGS-1157525 (NSF 2012a). GeoMIP prescribes matching suites of experiments to all its participating modeling teams, from institutions around the world, and also hosts an annual conference at which participants meet in person. It is endorsed by the World Climate Research Programme (WCRP).

4.5.4 Multi-focus

Some broad-based geoengineering research and development initiatives do not confine themselves to a single mode of technology, but instead explore a range of possibilities. For example:

4.5.4.1 Case: FICER

The Fund for Innovative Climate and Energy Research (FICER) is a project headquartered out of Harvard University, run by Dr. David Keith of the Harvard faculty and Dr. Ken Caldeira of the Carnegie Institute for Science. It is not a research project in itself, but makes grants to climate-related research projects, and since 2007 has funded 13 projects totaling roughly $4.6 million. FICER is funded from the personal resources of billionaire Bill Gates, co-founder of Microsoft.

In addition to traditional climate modeling and clean-energy research, FICER specifically identifies geoengineering-related areas of focus, including atmospheric carbon recapture ("developing technologies to remove carbon dioxide from the atmosphere") and solar radiation management ("researching approaches to reduce planetary absorption of solar radiation"). It does not fund field testing of SRM, but has done so for CDR. At least nine of its 13 funded projects have involved specifically geoengineering-related research projects, to the tune of $3.8 million (FICER 2018).

4.5.4.2 Case: SCRiM

The Sustainable Climate Risk Management network (SCRiM), centered at Penn State University, is a transdisciplinary team of scholars from across 19 universities and five research institutions in six different countries. Its mission is organized around answering a multi-part question: "What are sustainable, scientifically sound, technologically feasible, economically efficient, and ethically defensible climate risk management strategies?" (SCRiM Overview, 2018) Among its lead researchers is William Nordhaus of Yale, winner of the 2018 Nobel Prize in Economics for his work on climate change (together with Paul Romer of New York University, for his work on the role of policy in fostering technological innovation).

Out of SCRiM's twelve current "transdisciplinary projects," (SCRiM Projects, 2018) at least four directly involve geoengineering. In particular:

Project #2 examines how the high uncertainty of certain climate threshold responses (e.g., in the Greenland ice sheets) affects the efficiency trade-offs between emissions reduction, and other responses such as geoengineering.

Project #3 addresses the potential of solar geoengineering (i.e., SRM)—particularly stratospheric aerosols and cloud brightening—in light of its uneven regional impacts on temperature and other climate variables, using climate modeling to evaluate various combinations of geoengineering techniques and their ecosystem impacts, and examine strategies to minimize those impacts.

Project #5 examines how limits to local adaptive capacity influence the trade-offs with larger-scale efforts at both mitigation and geoengineering, and builds mental models of local decision-making processes.

Project #11 seeks to identify the scientific and ethical criteria necessary to assure effective international governance of geoengineering research and policies.

The SCRiM network is supported by the National Science Foundation under the NSF Directorate for Geosciences' cooperative agreement GEO-1240507 (NSF Award 2012b), an $11 million award dating to 2012 (and still ongoing) focused on climate risk management.

4.5.4.3 Case: EuTRACE

The European Transdisciplinary Assessment of Climate Engineering (EuTRACE) was a two-year project involving a consortium of independent experts from 14 institutions across five EU countries (Austria, France, Germany, Norway, and the UK), charged with studying and reporting on the current state of both CDR and SRM geoengineering technologies, and assessing their potential, risks, and implications. Related objectives included outreach to and dialogue with the public, policymakers, and other civil society stakeholders, and identifying future policy pathways and critical gaps in understanding (Schäfer et al. 2015).

EuTRACE was launched and coordinated by Germany's Institute for Advanced Sustainability Studies, and funded primarily by the EU's Seventh Framework Programme for research, technological development, and demonstration, which provided roughly €1,000,000 out of the project's overall budget of €1.36 million. In its final report it identified several promising possibilities and just as many challenges, but explicitly declined to reach any clear conclusions as to whether any specific geoengineering technology could be developed, scaled, and implemented in a way that would significantly reduce climate change, nor any conclusions about what the social and environmental costs of such an effort would be. It recommended a coordinated program of interdisciplinary research combined with stakeholder dialogue.

4.6 Analysis

Stated succinctly, the goal of this study is to discern the overall level of support from economically elite private and institutional actors for geoengineering projects to date, contingent on underlying conditions observed in the case studies. My expected outcome at the outset was that, as with economic elite individuals, elite interest groups and private actors would show significant openness to geoengineering solutions, with a clear relationship to their potential for commercialization and the degree of risk involved. While the limited sample size may impose constraints on generalizability, fsQCA analysis is designed to accommodate such limits even when they provide an obstacle to traditional quantitative analysis. The results of the fsQCA analysis follow, with corresponding discussion.

4.6.1 Results

After calibrating all the conditions for all the cases, I imported them into fsQCA software and constructed “truth tables.” As the overall N of 53 cases is not unduly large, the frequency threshold for inclusion of truth table rows (i.e., combinations of conditions) was set at ≥ one case; logically possible cases that do not exist empirically were excluded. Each row has a “raw consistency” score relative to the target outcome, on a scale of 0.0 to 1.0; sorted in descending order, the data show a clear empirical gap around the rule-of-thumb consistency level of 0.8, so rows below that value were excluded. I then conducted algorithmic analysis of these tables reflecting a variety of scenarios. Any counterfactual solution terms in each scenario were logically resolved on the basis of theoretical knowledge.

The first goal was to determine conditions (and combinations thereof) relevant to an outcome of successful membership in the set of cases with strong economic elite support. To this end, I conducted analyses involving various permutations of conditions, including a focus on either

CDR or SRM, a focus on only CDR or SRM, a focus on geoengineering regardless of type, a "maximum" model including all other potentially relevant conditions, a "minimum" model at the opposite extreme, and an "optimal" model containing those conditions considered most likely to be theoretically relevant.

The conclusions were broadly consistent. The inclusion of a generalized, nonspecific geoengineering focus (in addition to the specific degree of CDR or SRM focus) provided no added value to the results; as compared to the optimal model, the most "parsimonious solution" for this generalized model slightly increases the solution coverage (the portion of successful cases explained by the designated combinations of conditions), from 0.644 to 0.724, but the solution consistency score (indicating the extent to which the designated combinations can be relied upon as sufficient conditions leading to the outcome) is dramatically reduced, from 0.875 to a much more ambiguous 0.611. Consistency scores above 0.8 are generally considered substantive enough to establish a set relation (whereas those below 0.75 are considered unacceptable). With this confounding condition excluded, the parsimonious solution of the optimal model includes only theoretically sounds combinations, as seen in Table 4.2:

Table 4.2: Conditions Sufficient for Strong Elite Support

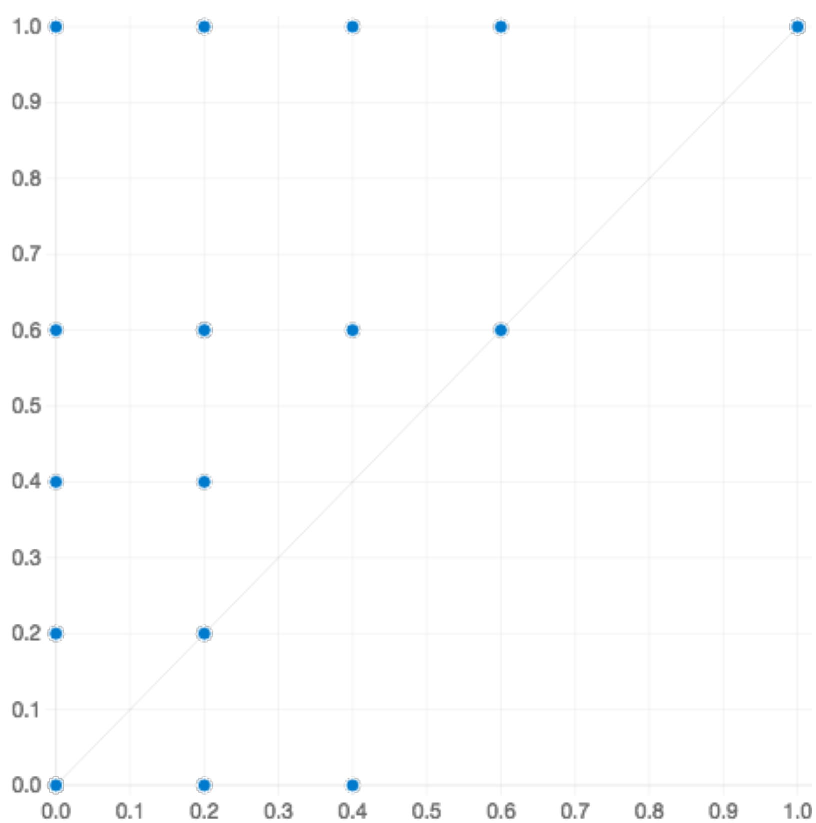
```
--- PARSIMONIOUS SOLUTION ---
frequency cutoff: 1
consistency cutoff: 0.826087
                                raw       unique
                              coverage   coverage   consistency
                             ---------- ---------- ----------
CDRfocus*Scope*Origin         0.448276   0.0689656  0.847826
CDRfocus*Origin*Locus         0.528736   0.114943   0.901961
CDRfocus*~DevStage*Origin     0.390805   0.0229886  0.894737

solution coverage: 0.643678
solution consistency: 0.875
```

(Each line represents a "solution term" combining relevant conditions in a way that also includes membership in the outcome set. "Raw coverage" measures the proportion of memberships in the outcome explained by each term in the solution. “Unique coverage” measures the proportion of memberships in the outcome explained solely by each individual solution term, excluding all others. “Consistency” measures the extent to which each solution term is a subset of the outcome, i.e., sufficient to produce that outcome. “Solution coverage” and “solution consistency” represent these measurements for the full set of solution terms. More complex, less parsimonious solution sets are included in the Appendix; it is clear to see that these do not logically enhance nor contradict the parsimonious set.)

It is also possible to visualize fuzzy set relations with a chart. For example, the highest scoring solution term in the set above (representing cases’ degree of membership in the combination *CDRfocus*Origin*Locus*) can be charted against the outcome as seen in Figure 4.1, below. A plot with cases situated predominantly above the line signals a consistent relationship.

Figure 4.1: Strong elite support (Y axis) vs. Membership in Solution Set (X axis)



The specific cases represented in the solution set are (for the first solution term) Carbon Engineering, Carbon180/CarbonTech Labs, Global Research Technologies/Kilimanjaro Energy, the VirginEarth Challenge, and the Y-Combinator Carbon Removal Startup Project; (for the second solution term) Carbon180/CarbonTech Labs, Climos Inc., Global Research Technologies/Kilimanjaro Energy, Global Thermostat, Infinitree/Carbon Sink, the Haida Corporation, and the Y-Combinator; and (for the third solution term) Carbon180/CarbonTech Labs, Climos Inc., Haida Corp., Ocean Nourishment Corp., and the Y-Combinator. Allowing for overlaps, this is a combined set of ten cases.

Meanwhile, clearly, projects focused on SRM drop out of the solution. The conditions that are common to each and every solution term are membership in the set of projects related to CDR, together with membership in the set of projects originating in the private sector… in combination with any one of three other conditions, specifically a broad geographic scope, an American locus of operations, or an early developmental stage (the ~ symbol signifies negation). Taken on their own, CDR and sector of origin each presents itself as an INUS condition—that is to say, an **i**nsufficient but **n**ecessary part of solution terms that are themselves each **u**nnecessary but **s**ufficient.

Interestingly, omitting institutional constraints from the model produced the exact same solution terms and measurements, suggesting that such constraints are simply not (at least, not yet) a relevant factor related to elite support. On the other hand, omitting either CDR or SRM cases only served to reduce the clarity of the solution.

As a complementary analysis, since the causal logic of fsQCA analysis is inherently asymmetric, I also modeled scenarios relevant to non-occurrence of the outcome—that is to say, an outcome *negating* membership in the set with strong economic elite support. With or without institutional constraints included, the optimal model's parsimonious solution was as seen in Table 4.3:

Table 4.3: Conditions Sufficient for Lack of Strong Elite Support

```
--- PARSIMONIOUS SOLUTION ---
frequency cutoff: 1
consistency cutoff: 0.857143
                     raw       unique
                   coverage   coverage    consistency
                  ----------  ----------  ----------
~Origin            0.769663    0.35955     0.958042
~CDRfocus*~Locus   0.168539    0.0393258   0.9375
SRMfocus*Scope     0.41573     0.0393258   0.891566

solution coverage: 0.85955
solution consistency: 0.916168
```

The included solution terms appear logically related to the solution terms for the successful cases. Specifically, to be included in the set of cases *least* likely to have strong elite support, it is sufficient for a project to originate outside the private sector, to demonstrate a lack of CDR focus combined with operations outside the U.S., *or* to have a focus on SRM combined with a broad geographic scope.

4.7 Discussion

From the analysis of the geoengineering case studies included here, it seems clear that there are important criteria common to the project that attract support from the kind of economic elite individuals and institutions likely to wield significant influence among policymakers.

Specifically, it is important that a project be substantially related to CDR technologies, and that it originate in the private sector, together with any one of three additional conditions (U.S.-based operations, an early stage of R&D, or a broad geographic scope). SRM technologies clearly do not attract the same kind of elite support (although they may garner support from government agencies or nonprofit organizations), despite their lower financial barriers to entry and their potentially faster benefits.

The reasons for this contrast are uncertain, but one might reasonably suppose that they include the perceptions of greater risk associated with SRM and the concomitant near-consensus that such projects be limited only to purely scientific research on a small and controlled scale, whereas CDR projects are perceived to be more scalable and present clearer prospects for commercialization.

From these findings, we can draw provisional conclusions for policy entrepreneurs seeking politically feasible policy responses to climate change. It appears that SRM research is likely to be consigned to the back burner for the foreseeable future, while CDR (*aka* NET) becomes more economically and politically salient. Meanwhile, although projects based in other countries may provide guidance as to best practices for American researchers, they are unlikely to catch the attention of domestic elites or policymaker on their own, unless or until replicated in the United States.

4.8 Appendix

4.8.A1—Full Table of Cases

Case	Area of focus	Sub-category	CDRfocus	SRMfocus	GEOfocus	DevStage	Scope	Origin	Locus	InstConstraints	EliteSupp
Academy of Finland	SRM	Strat Aerosols	0.00	1.00	0.00	0.4	1.00	0.00	0.20	0.20	0.00
Alberta CCTC	CCS	Conversion	0.20	0.00	0.20	0.6	1.00	0.00	0.20	0.00	0.00
Arizona Public Service Co.	CCS	Algae	0.20	0.00	0.20	0.6	0.60	1.00	1.00	0.00	0.00
ASU Center for Negative Carbon Emissions (Klaus Lackner)	CDR	DAC	1.00	0.00	1.00	0.6	0.60	0.00	1.00	0.00	0.00
Berkeley Artifical Trees	CDR	DAC	1.00	0.00	0.00	0.4	0.80	0.00	1.00	0.00	0.00
Carbo Culture	CDR	Biochar	0.40	0.00	0.40	0.8	0.20	1.00	1.00	0.00	0.60
Carbon Engineering	CDR	DAC	1.00	0.00	1.00	0.8	1.00	1.00	0.20	0.00	1.00
Carbon Xprize	CCS	Conversion	0.20	0.00	0.20	0.6	0.20	1.00	0.60	0.00	0.60
Carbon180/ CarbonTech Labs	CDR		1.00	0.00	1.00	0.4	1.00	1.00	1.00	0.00	1.00
Carbon180/New Carbon Economy Consortium	CDR		1.00	0.00	1.00	0.4	1.00	0.20	1.00	0.00	0.20
CDRMIP	CDR		1.00	0.00	1.00	0.2	1.00	0.00	0.20	0.00	0.00
Climate Engineering Priority Program	CDR		1.00	0.00	1.00	0.2	1.00	0.00	0.20	0.00	0.00
Climate Engineering Scoping Report	SRM, CDR		1.00	1.00	1.00	0.2	1.00	0.00	0.20	0.00	0.00
Climate Foundation	CDR	Upwelling	0.80	0.00	0.80	0.4	0.20	0.20	1.00	0.00	0.20
ClimeWorks AG (Switzerland)	CDR	DAC	1.00	0.00	1.00	0.8	0.40	1.00	0.20	0.00	1.00
Climos, Inc.	CDR	Ocean Fertilization	0.60	0.00	0.60	0.4	0.20	1.00	1.00	0.80	1.00
CoolPlanet	CDR	Biochar	0.40	0.00	0.20	0.8	0.20	1.00	1.00	0.00	1.00
EuTRACE	SRM, CDR		1.00	1.00	1.00	0.4	1.00	0.00	0.20	0.00	0.20
FICER	SRM, CDR		1.00	1.00	0.80	0.4	1.00	0.20	1.00	0.00	0.60

4.8.A1—Full Table of Cases (continued)

Case	Area of focus	Sub-category	CDRfocus	SRMfocus	GEOfocus	DevStage	Scope	Origin	Locus	InstConstraints	EliteSupp
G4 Foam Experiment (Robock)	SRM	Microbubbles	0.00	1.00	1.00	0.4	1.00	0.20	1.00	0.00	0.00
GeoMIP	SRM		0.00	1.00	1.00	0.4	1.00	0.00	1.00	0.00	0.00
Global Research Technologies/ Kilimanjaro Energy (Lackner)	CDR	DAC	1.00	0.00	1.00	0.6	0.80	1.00	1.00	0.00	1.00
Global Thermostat	CDR	DAC	1.00	0.00	1.00	0.8	0.20	1.00	1.00	0.00	1.00
Haida Corp.	CDR	Ocean Fertilization	0.60	0.00	0.60	0.4	0.20	1.00	0.60	0.80	0.60
Harvard Solar Geo. Research Program	SRM		0.00	1.00	1.00	0.2	0.20	0.20	1.00	0.00	0.40
IAGP (Integrated Assmt of Geo. Proposals)	SRM, CDR		1.00	1.00	1.00	0.4	1.00	0.00	0.20	0.00	0.00
Ice911	SRM	Albedo mod	0.00	1.00	1.00	0.6	1.00	0.20	1.00	0.00	0.20
Infinitree/Carbon Sink	CDR	DAC	1.00	0.00	1.00	0.6	0.20	1.00	1.00	0.00	1.00
ISU Initiative for a Carbon Negative Economy	CDR	Biochar	0.40	0.00	0.40	0.4	0.20	0.00	1.00	0.00	0.00
Keith Group A (solid aerosols)	SRM	Stratospheric Aerosols	0.00	1.00	1.00	0.4	0.20	0.20	1.00	0.20	0.20
Keith Group B (W'head, governance)	SRM, CDR		1.00	1.00	1.00	0.2	0.20	0.20	1.00	0.00	0.00
Keith Group C (SRM & sea level)	SRM		0.00	1.00	1.00	0.2	0.20	0.20	1.00	0.00	0.00
Leverhulme Centre Field Trials	CDR	Enhanced Weathering	0.80	0.00	0.80	0.4	1.00	0.20	0.20	0.00	0.20
Marine Cloud Brightening Project	SRM	Cloud brightening	0.00	1.00	1.00	0.4	0.20	1.00	1.00	0.00	0.00
Microbubbles LLC	SRM	Microbubbles	0.00	1.00	1.00	0.4	0.20	1.00	1.00	0.00	1.00
Oak Ridge National Laboratory	CDR	DAC	1.00	0.00	1.00	0.4	0.80	0.00	1.00	0.00	0.00

4.8.A1—Full Table of Cases (continued)

Case	Area of focus	Sub-category	CDRfocus	SRMfocus	GEOfocus	DevStage	Scope	Origin	Locus	InstConstraints	EliteSupp
Ocean Nourishment Corporation	CDR	Ocean Fertilization	0.60	0.00	0.60	0.4	0.20	1.00	0.20	0.80	1.00
Pacific Biochar	CDR	Biochar	0.40	0.00	0.40	0.8	0.20	1.00	1.00	0.00	0.00
Pond Technologies	CDR	Algae	0.40	0.00	0.40	0.8	0.40	1.00	0.20	0.00	0.00
Princeton CMI	CDR		1.00	0.00	0.20	0.4	1.00	0.20	1.00	0.00	0.60
Rutgers SAI project (Robock)	SRM	Strat Aerosols, Sun Shading	0.00	1.00	1.00	0.4	1.00	0.00	1.00	0.20	0.00
SCoPEx	SRM	Stratospheric Aerosols	0.00	1.00	1.00	0.4	0.20	0.20	1.00	0.40	0.20
SCRIM	SRM		0.00	1.00	0.20	0.4	1.00	0.00	1.00	0.00	0.00
Ship wake brightening (UK)	SRM	Microbubbles	0.00	1.00	1.00	0.4	0.20	0.00	0.20	0.00	0.00
SNOWIE cloud seeding	SRM	Cloud seeding	0.00	1.00	1.00	0.4	0.40	0.00	1.00	0.00	0.00
Soletair (Finland)	CDR	DAC	1.00	0.00	1.00	0.6	0.40	1.00	0.20	0.00	0.40
SPICE	SRM	Strat Aerosols	0.00	1.00	1.00	0.4	1.00	0.00	0.20	0.40	0.00
SRMGI	SRM		0.00	1.00	1.00	0.4	1.00	1.00	0.60	0.00	0.00
SSCE	SRM	Strat Aerosols	0.00	1.00	1.00	0.4	1.00	0.00	0.20	0.40	0.00
StratoShield from Intellectual Ventures Lab	SRM	Strat Aerosols	0.00	1.00	1.00	0.4	1.00	1.00	1.00	0.40	0.60
Virgin Earth Challenge (11 finalists, inc. 4 geo.)	CDR		1.00	0.00	1.00	0.6	1.00	1.00	0.20	0.00	0.60
White Roofs Research	SRM	Albedo mod	0.00	1.00	0.00	0.4	0.60	0.00	1.00	0.00	0.00
Y-Combinator (Carbon Removal Startups)	CDR		1.00	0.00	1.00	0.4	1.00	1.00	1.00	0.00	1.00

4.8.A2—Additional fsQCA Solution Sets

(Optimal scenario, outcome = strong economic elite support)

```
--- COMPLEX SOLUTION ---
frequency cutoff: 1
consistency cutoff: 0.84
                                                 raw       unique
                                               coverage   coverage   consistency
                                              ---------- ---------- ----------
CDRfocus*~SRMfocus*Origin*Locus               0.517241   0.195402   0.918367
CDRfocus*~SRMfocus*~DevStage*~Scope*Origin    0.229885   0.0229886  0.869565
CDRfocus*~SRMfocus*DevStage*Scope*Origin      0.344828   0.0689656  0.882353

solution coverage: 0.62069
solution consistency: 0.915254
```

(Maximum scenario, outcome = strong economic elite support)

```
--- COMPLEX SOLUTION ---
frequency cutoff: 1
consistency cutoff: 0.826087
                                                                raw       unique
                                                              coverage   coverage   consistency
                                                             ---------- ---------- ----------
CDRfocus*~SRMfocus*~DevStage*~Scope*Origin*InstConstraints   0.103448   0.0689656  1
CDRfocus*~SRMfocus*DevStage*Scope*Origin*~InstConstraints    0.344828   0.0804598  0.882353
CDRfocus*~SRMfocus*DevStage*Origin*Locus*~InstConstraints    0.344828   0.0804598  0.882353
CDRfocus*~SRMfocus*Scope*Origin*Locus*~InstConstraints       0.344828   0.0804598  0.909091

solution coverage: 0.574713
solution consistency: 0.909091
```

4.8.A2—Additional fsQCA Solution Sets (continued)

(Optimal scenario, outcome = lack of strong economic elite support)

```
--- COMPLEX SOLUTION ---
frequency cutoff: 1
consistency cutoff: 0.857143
                                                                   raw       unique
                                                                 coverage   coverage  consistency
                                                                ---------- ---------- ----------
~CDRfocus*SRMfocus*~DevStage*~Origin*~InstConstraints           0.252809   0.0449438  0.978261
~DevStage*~Scope*~Origin*Locus*~InstConstraints                 0.185393   0.0393259  0.970588
CDRfocus*~DevStage*Scope*~Origin*~InstConstraints               0.224719   0.11236    0.952381
CDRfocus*~SRMfocus*Scope*~Origin*Locus*~InstConstraints         0.129213   0.022472   0.92
~CDRfocus*SRMfocus*Scope*~Origin*Locus*~InstConstraints         0.196629   0.0449437  1
~CDRfocus*SRMfocus*~DevStage*Scope*Locus*~InstConstraints       0.185393   0.0337079  0.942857
~CDRfocus*~SRMfocus*DevStage*Scope*~Origin*~Locus*~InstConstrnts 0.0224719 0.011236   1
~CDRfocus*~SRMfocus*DevStage*~Scope*Origin*~Locus*~InstConstrnts 0.0337079 0.0337079  0.857143

solution coverage: 0.662921
solution consistency: 0.944
```

5 CONCLUSION

Every journey must have an end. While it seems inherent in the nature of dissertation research to expend indefinitely like a fractal, no matter how deeply one delves into it, that elusive endpoint does eventually materialize, presenting the opportunity to collect one's thoughts and reflect. To conclude, then, I will review the major findings of this dissertation and the lessons learned, consider a few of the challenges and limitations encountered along the way, and suggest potentially fruitful directions for both future research and policy formation.

5.1 Review of Findings

The overarching aim of this dissertation has been to seek ways to navigate the metaphorical minefield of political obstacles to policy formation on climate change, a wickedly complex problem that looms over modern civilization.

In **Chapter One**, I attempted to construct a compass that can help with that navigation, its true north the principle that no matter how well-designed, any policy that falls short of real-world political viability can be neither effective nor efficient. I described two of the major forces impeding that viability, which intersect in the climate policy domain. First is ideological polarization by party, which both negatively impacts government's ability to act on policy problems, and increases the disconnect between public opinion and substantive policy considerations. Second is increasing economic inequality, which has produced corresponding increases in representational inequality.

Political resistance, however, is not uniform. It can and will vary depending on the options on offer. I therefore provided an overview of the traditional range of policy instruments, including "command-and-control" regulations and "market-based" incentive structures, and climate policy instruments in particular, including both mitigation and adaptation approaches. I then introduced an alternative to the traditional taxonomies, in the form of emerging technologies for geoengineering. While there are no panaceas in the world of policy design, and geoengineering does not offer one where the long-term threat of climate change is concerned, it does offer an additional array of stabilization techniques beyond those routinely considered and debated. Politically speaking, it has also shown promise where public opinion is concerned, although the opinions of economic elites remained to be examined.

In **Chapter Two**, I investigated the process of state-level adoption of innovative climate policies (primarily the renewable portfolio standard), taking a two-pronged multi-method approach, sequentially quantitative then qualitative. Through statistical event history analysis and through semi-structured interviews with policy actors, I demonstrated that specific energy- and climate-related policies, and the design details thereof, appear to be relatively low-salience for the general public, although voters support "environmental" issues as a category. I also confirmed that stronger substantive policies in a state result only when the government itself is sufficiently ideologically liberal to muster both the issue-level commitment and the political wherewithal to pass legislation despite opposition from conservatives and industry. In this regard, contextual factors influencing the decisions of policy actors include the political characteristics of the state, as well as governmental norms of trust, reciprocity, information sharing, and deliberation.

In **Chapter Three**, I investigated the attitudes of individual economic elites, which both the literature on inequality and the abovementioned findings indicate often dominate the political behavior of policymakers. I did this through a customized survey experiment, gathering data on the views of economic elite individuals and subjecting it to painstaking analysis.

Contrary to expectations based on general public opinion, the results clearly suggest that priming and framing climate-related information in terms of geoengineering as opposed to regulation does *not* have a statistically significant impact on the attitudes of economic elites. That result is not itself discouraging, as climate change turns out to be highly salient to economic elites regardless of how potential policy responses are framed; thus elite attitudes are congruent with (or ahead of) the general public, which ordinarily creates opportunity space for policy formation. However, while economic elites in aggregate apparently want to see action on the climate crisis, the data analysis also shows that far and away the most significant variable dividing that group is party identification. Thus it appears that polarization trumps even economic status, at least where individual preferences are concerned.

What about the institutional level? In **Chapter Four** I investigated the revealed preferences of elite (business and industrial) organized interests, as seen through their support for specific geoengineering research programs and policy initiatives. The approach was mixed-method, employing qualitative comparative analysis (QCA) to interpret a carefully identified set of case studies and their underlying conditions. The results make clear that that there are important criteria common to the geoengineering projects that have attracted support from the kind of economic elite institutions and (policy) entrepreneurs likely to wield significant influence among policymakers. Specifically, it is important that a project be substantially related to carbon dioxide removal (CDR) technologies, as opposed to solar radiation management (SRM), and that it have private-sector origins… together with any one of three additional conditions (i.e., U.S.-based operations, early-stage R&D, or a broad geographic scope).

5.2 Theoretical Contributions

This dissertation replicates, refines, and expands on multiple strands of research involving policy formation on climate change, with a special focus on geoengineering technologies. It adds to that research by adopting an approach focused on both economic-elite influence and ideological polarization, two rapidly evolving areas of political science research, as boundary conditions for political viability. In doing so, it unites three strands of literature—one focused on analyzing policy instruments, in which political factors are largely neglected; one focused on how polarization and inequality impact representation and governance, in which policy options matter only as examples; and one focused on modes of communicating and measuring policy risks, information flows, and opinion formation. Throughout a wide range of variations in methodology and units of analysis, it keeps one theoretical proposition front and center: scholars cannot avoid taking into account an empirically informed understanding of political viability, as not just a cost factor but indeed a litmus test, for any policy analysis that intends to have real-world relevance, in the climate domain and beyond.

5.3 Methodological Challenges

Long before I pursued doctoral studies, I trained in law. Legal scholarship is inherently qualitative and inductive, oriented around details of context, thick description, and the inevitability that no fact pattern is impervious to multiple interpretations, although ultimately a court can exercise decisive authority.

Social science research is a different beast, dominated (although never exclusively) by a quantitative approach. It is resolutely deductive, grounded in empirical data yet at the same time often highly abstracted from any particular real-world circumstances. Unlike the law, in which one sometimes has recourse to Supreme Court decisions, social science scholarship also explicitly precludes any authoritative statement of How Things Must Be.

I am not a statistician nor have I ever wished to be one. I value the understanding of probability and quantitative reasoning I have acquired through my doctoral studies, and the toolbox of econometric skills I have accumulated along the way. At the same time, I am keenly aware of the ways scholarly disciplines silo themselves off from one another, and the risks this poses. I appreciate an interdisciplinary and indeed intersubjective approach to social inquiry. I find the study of politics and policy compelling for the potential they offer to craft a world that is more just and humane, not to explore new ways to utilize the tools in my toolbox.

With these values in mind, I could not and would not have pursued dissertation research that approached everything through the lens of parametric data analysis. I sought out and combined multiple methods, letting my choices be shaped by the nature of the questions before me, rather than letting the questions be shaped by the tools at hand. Many of these tools were previously unfamiliar to me and, indeed, to the scholars and colleagues from who I sought guidance. Nonetheless, from multinomial logit regressions to semi-structured interviews, from survey design to confirmatory factor analysis to the intricacies of analyzing Likert-scale data, from case-study selection to qualitative comparative analysis, and beyond, I believe I identified, engaged with, and learned from the methods most suitable to the subject matter at hand.

I hope that in the process I have done justice to these methods, and to the real and pressing issues on which they were brought to bear.

5.4 Limitations and Future Research

This research has, unavoidably, touched on many issues that go beyond what it can explore directly. Among these are the overall technological feasibility of various geoengineering proposals, the ethical implications of same, and their relevance to international climate negotiations, all of which are well beyond the scope of this dissertation. Closer to home are issues such as the emergence of suitable legal and regulatory governance regimes for geoengineering as it moves from R&D to reality; the federalism implications of initiatives pursued at the state level; and post-enactment policy inertia (regardless of effectiveness), which some states have already experienced with renewable energy policies. It might also be enlightening to explore why some environmental issue activists seem to be *less* receptive to geoengineering options than the broader public.

More broadly, the intersection of polarization and inequality poses daunting challenges to some of our most closely held assumptions about democracy. If the support of economic elites is necessary but not itself sufficient for policy formation to be politically viable, what else might be needed? Issues such as these offer fruitful and in many cases crucial avenues for future research, and I hope to address many of them in due time.

5.5 Concluding Thoughts and Implications

The criteria that characterize the most promising prospects for geoengineering projects and policies, according to the research contained in this dissertation, seem strongly related to perceived market opportunities, as opposed to any conventional scholarly criteria for policy analysis. Nevertheless, that hardly disqualifies them from consideration when we remember the lodestone of political viability. Taking explicit account of political viability might allow advocates and policymakers to design, shift attention to, and ultimately enact policies that—even if not strictly optimal according to rigorous scholarly criteria—could achieve greater strides toward mitigating and adapting to the threat of climate change than alternatives that remain perpetually on the drawing board.

From the findings herein, we can draw provisional conclusions for policy entrepreneurs seeking such politically feasible policy responses to climate change. They are policy options that can be framed effectively for both the general public and economic elites, for both policymakers and stakeholders… and that can be promoted without reflexively generating prohibitively high levels of political resistance.

In the end, I anticipate that in terms of political viability, geoengineering will stand revealed as a promising arena for future climate policy efforts at multiple levels—less vulnerable to partisan power dynamics, conflict extension, gridlock, and potentially judicial delay, compared to past efforts. If it is possible to integrate realistic criteria for political viability with existing scientific and economic assessments, that may yet point an easier way toward least-resistance pathways to effective policy.

In other words: a path through the minefield?

References

References for Chapter One

Abramowitz, Alan I., and Kyle L. Saunders. 2008. "Is Polarization a Myth?" The Journal of Politics 70(2): 542–55.

Bartels, Larry M. 2008. Unequal Democracy: The Political Economy of the New Gilded Age. Princeton University Press.

Bellamy, Rob, Jason Chilvers, Naomi E. Vaughan, and Timothy M. Lenton. 2012. "A Review of Climate Geoengineering Appraisals." WIREs Climate Change 3(6): 597–615.

Carley, Sanya, and Chris J. Miller. 2012. "Regulatory Stringency and Policy Drivers: A Reassessment of Renewable Portfolio Standards." Policy Studies Journal 40(4): 730–756.

Carsey, Thomas M., and Geoffrey C. Layman. 2006. "Changing Sides or Changing Minds? Party Identification and Policy Preferences in the American Electorate." American Journal of Political Science 50(2): 464–477.

Cole, Daniel H. 2008. "Climate Change and Collective Action." Current Legal Problems 61(1): 229–64.

Cummings, Christopher L., and Sonny Rosenthal. 2018. "Climate Change and Technology: Examining Opinion Formation of Geoengineering." Environment Systems and Decisions 38(2): 208–15.

Davis, Steven J, Long Cao, Ken Caldeira, and Martin I Hoffert. 2013. "Rethinking Wedges." Environmental Research Letters 8(1): 011001.

Enkvist, Per-Anders, Jens Dinkel, and Charles Lin. 2010. Impact of the Financial Crisis on Carbon Economics: Version 2.1 of the Global Greenhouse Gas Abatement Cost Curve. McKinsey and Company.

Fiorina, Morris P., and Samuel J. Abrams. 2008. "Political Polarization in the American Public." Annual Review of Political Science 11(1): 563–88.

Fullerton, Don. 2001. "A Framework to Compare Environmental Policies." Southern Economic Journal 68(2): 224.

Gilens, Martin. 2012. Affluence and Influence: Economic Inequality and Political Power in America. Princeton University Press. https://www.russellsage.org/economic-inequality-and-political-representation.

———. 2015. "The Insufficiency of 'Democracy by Coincidence': A Response to Peter K. Enns." Perspectives on Politics 13(04): 1065–71.

Gilens, Martin, and Benjamin I. Page. 2014. "Testing Theories of American Politics: Elites, Interest Groups, and Average Citizens." Perspectives on Politics 12(03): 564–81.

Goulder, L. H., and I. W. H. Parry. 2008. “Instrument Choice in Environmental Policy.” Review of Environmental Economics and Policy 2(2): 152–74.

Gromet, Dena M., Howard Kunreuther, and Richard P. Larrick. 2013. “Political Ideology Affects Energy-Efficiency Attitudes and Choices.” Proceedings of the National Academy of Sciences 110(23): 9314–19.

Hacker, Jacob S., and Paul Pierson. 2011. Winner-Take-All Politics: How Washington Made the Rich Richer--and Turned Its Back on the Middle Class. Simon and Schuster.

Hawken, Paul. 2017. Drawdown: The Most Comprehensive Plan Ever Proposed to Reverse Global Warming. Penguin.

Heyward, Clare. 2013. “Situating and Abandoning Geoengineering: A Typology of Five Responses to Dangerous Climate Change.” PS: Political Science & Politics 46(01): 23–27.

Himelfarb, Alex. 2011. “Tax Isn’t a Four-Letter Word.” The Globe and Mail. 1 (September 21, 2017).

Iyengar, Shanto, Gaurav Sood, and Yphtach Lelkes. 2012. “Affect, Not Ideology: A Social Identity Perspective on Polarization.” Public opinion quarterly 76(3): 405–431.

Kahan, Dan M. et al. 2012. “The Polarizing Impact of Science Literacy and Numeracy on Perceived Climate Change Risks.” Nature climate change 2(10): 732–735.

———. 2015. “Geoengineering and Climate Change Polarization: Testing a Two-Channel Model of Science Communication.” The ANNALS of the American Academy of Political and Social Science 658(1): 192–222.

Kahan, Dan M., Hank Jenkins-Smith, and Donald Braman. 2011. “Cultural Cognition of Scientific Consensus.” Journal of Risk Research 14(2): 147–74.

Kallbekken, Steffen, Stephan Kroll, and Todd L. Cherry. 2011. “Do You Not like Pigou, or Do You Not Understand Him? Tax Aversion and Revenue Recycling in the Lab.” Journal of Environmental Economics and Management 62(1): 53–64.

Keohane, Robert O., and David G. Victor. 2011. “The Regime Complex for Climate Change.” Perspectives on Politics 9(01): 7–23.

Krutilla, Kerry. 2011. “Transaction Costs and Environmental Policy: An Assessment Framework and Literature Review.” International Review of Environmental and Resource Economics 4(3–4): 261–354.

Lax, Jeffrey R., and Justin H. Phillips. 2012. “The Democratic Deficit in the States.” American Journal of Political Science 56(1): 148–66.

Layman, Geoffrey C. et al. 2010. “Activists and Conflict Extension in American Party Politics.” American Political Science Review 104(02): 324–46.

Layman, Geoffrey C., Thomas M. Carsey, and Juliana Menasce Horowitz. 2006. "Party Polarization in American Politics: Characteristics, Causes, and Consequences." Annual Review of Political Science 9(1): 83–110.

Lazarus, Richard J. 2009. "Super Wicked Problems and Climate Change: Restraining the Present to Liberate the Future." Cornell L. Rev. 94: 1153.

Levendusky, Matthew. 2009. The Partisan Sort: How Liberals Became Democrats and Conservatives Became Republicans. University of Chicago Press.

Levin, Kelly, Benjamin Cashore, Steven Bernstein, and Graeme Auld. 2012. "Overcoming the Tragedy of Super Wicked Problems: Constraining Our Future Selves to Ameliorate Global Climate Change." Policy Sciences 45(2): 123–52.

Marquart-Pyatt, Sandra T. et al. 2011. "Understanding Public Opinion on Climate Change: A Call for Research." Environment: Science and Policy for Sustainable Development 53(4): 38–42.

Metcalf, Gillbert E., and David Weisbach. 2009. "The Design of a Carbon Tax." Harvard Environmental Law Review 33: 499.

Nauclér, Tomas, and Per-Anders Enkvist. 2009. Pathways to a Low-Carbon Economy: Version 2 of the Global Greenhouse Gas Abatement Cost Curve. McKinsey and Company.

Nelson, Hal T. et al. 2015. "Intergovernmental Climate Change Mitigation Policies: Theory and Outcomes." Journal of Public Policy 35(01): 97–136.

Nordhaus, W. D. 2007. "To Tax or Not to Tax: Alternative Approaches to Slowing Global Warming." Review of Environmental Economics and Policy 1(1): 26–44.

Pacala, Stephen, and Robert H. Socolow. 2004. "Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies." Science 305(5686): 968–72.

Pidgeon, N. et al. 2012. "Exploring Early Public Responses to Geoengineering." Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences 370(1974): 4176–96.

Richards, Kenneth R. 2000. "Framing Environmental Policy Instrument Choice." Duke Envtl. L. & Pol'y F. 10: 221.

Rittel, Horst WJ, and Melvin M. Webber. 1973. "Dilemmas in a General Theory of Planning." Policy sciences 4(2): 155–169.

Schelling, Thomas C. 1983. "Climatic Change: Implications for Welfare and Policy." In Changing Climate: Report of the Carbon Dioxide Assessment Committee, Washington, DC: National Academy Press, 449–82.

Schneider, S. H. 2008. "Geoengineering: Could We or Should We Make It Work?" Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences 366(1882): 3843–62.

Shapiro, R. Y. 2011. “Public Opinion and American Democracy.” Public Opinion Quarterly 75(5): 982–1017.

Shepherd, John G. et al. 2009. Geoengineering the Climate: Science, Governance and Uncertainty. London, UK: The Royal Society. https://royalsociety.org/~/media/Royal_Society_Content/policy/publications/2009/8693.pdf.

———. 2012. “Geoengineering the Climate: An Overview and Update.” Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences 370(1974): 4166–75.

Sinclair, Barbara. 2009. “Partisan Polarization, Rules and Legislative Productivity.” https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1450627 (January 19, 2017).

Socolow, Robert H., and Alexander Glaser. 2009. “Balancing Risks: Nuclear Energy & Climate Change.” Daedalus 138(4): 31–44.

Stavins, Robert N. 2003. “Market-Based Environmental Policies: What Can We Learn from US Experience (and Related Research)?” https://papers.ssrn.com/sol3/papers.cfm?abstract_id=421720 (January 19, 2017).

Sunstein, Cass R. 2007. “On the Divergent American Reactions to Terrorism and Climate Change.” Columbia Law Review: 503–557.

Wendling, Zachary et al. 2013. “On the Importance of Strengthening Moderate Beliefs in Climate Science to Foster Support for Immediate Action.” Sustainability 5(12): 5153–70.

Wildavsky, Aaron. 1987. “Choosing Preferences by Constructing Institutions: A Cultural Theory of Preference Formation.” American Political Science Review 81(01): 3–21.

References for Chapter Two

AB-32, California Global Warming Solutions Act of 2006. 2006. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=200520060AB32.

Adams, William C. 2015. "Conducting Semi-Structured Interviews." In *Handbook of Practical Program Evaluation*, eds. Kathryn E. Newcomer, Harry P. Hatry, and Joseph S. Wholey. John Wiley & Sons, Ltd, 492–505. https://onlinelibrary.wiley.com/doi/abs/10.1002/9781119171386.ch19 (June 10, 2020).

Baumgartner, Frank R., and Bryan D. Jones. 2009. *Agendas and Instability in American Politics*. 2nd ed. University of Chicago Press.

Berry, Frances Stokes, and William D. Berry. 1990. "State Lottery Adoptions as Policy Innovations: An Event History Analysis." *American Political Science Review* 84(2): 395–415.

Berry, W. D. et al. 2010. "Measuring Citizen and Government Ideology in the U.S. States: A Re-Appraisal." *State Politics & Policy Quarterly* 10(2): 117–35.

Berry, William D., Evan J. Ringquist, Richard C. Fording, and Russell L. Hanson. 1998. "Measuring Citizen and Government Ideology in the American States, 1960-93." *American Journal of Political Science* 42(1): 327–48.

———. 2007. "The Measurement and Stability of State Citizen Ideology." *State Politics & Policy Quarterly* 7(2): 111–32.

———. 2015. "Assessing the Validity of Enns and Koch's Measure of State Policy Mood." *State Politics & Policy Quarterly* 15(4): 425–435.

Blandford, Ann E. 2013. "Semi-Structured Qualitative Studies." In *The Encyclopedia of Human-Computer Interaction*, eds. Mads Soegaard and Rikke Friis Dam. Interaction Design Foundation.

Bromley-Trujillo, Rebecca, J. S. Butler, John Poe, and Whitney Davis. 2016. "The Spreading of Innovation: State Adoptions of Energy and Climate Change Policy: The Spreading of Innovation." *Review of Policy Research* 33(5): 544–65.

Broockman, David E., and Christopher Skovron. 2017. "Bias in Perceptions of Public Opinion Among American Political Elites."

Buckley, Jack, and Chad Westerland. 2004. "Duration Dependence, Functional Form, and Corrected Standard Errors: Improving EHA Models of State Policy Diffusion." *State Politics & Policy Quarterly* 4(1): 94–113.

Carley, Sanya. 2009. "State Renewable Energy Electricity Policies: An Empirical Evaluation of Effectiveness." *Energy Policy* 37(8): 3071–81.

Carley, Sanya, and Chris J. Miller. 2012. "Regulatory Stringency and Policy Drivers: A Reassessment of Renewable Portfolio Standards." *Policy Studies Journal* 40(4): 730–756.

Caughey, Devin, and Christopher Warshaw. 2015. "Dynamic Estimation of Latent Opinion Using a Hierarchical Group-Level IRT Model." *Political Analysis* 23(02): 197–211.

———. 2016. "The Dynamics of State Policy Liberalism, 1936–2014." *American Journal of Political Science* 60(4): 899–913.

———. 2018. "Policy Preferences and Policy Change: Dynamic Responsiveness in the American States, 1936–2014." *American Political Science Review* 112(2): 249–66.

Chandler, Jess. 2009. "Trendy Solutions: Why Do States Adopt Sustainable Energy Portfolio Standards?" *Energy Policy* 37(8): 3274–81.

Cole, Daniel, Graham Epstein, and Michael McGinnis. 2019. "The Utility of Combining the IAD and SES Frameworks." *International Journal of the Commons* 13(1): 244–75.

Corbin, Juliet, and Anselm Strauss. 2007. *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*. 3rd ed. SAGE Publications.

Enns, Peter K., and Julianna Koch. 2013. "Public Opinion in the US States: 1956 to 2010." *State Politics & Policy Quarterly* 13(3): 349–372.

Gerring, John. 2017. "Qualitative Methods." *Annual Review of Political Science* 20(2017): 15–36.

Gilens, Martin, and Benjamin I. Page. 2014. "Testing Theories of American Politics: Elites, Interest Groups, and Average Citizens." *Perspectives on Politics* 12(03): 564–81.

Henry, Devin. 2015. "Shell to Leave ALEC over Climate Change Stance." *TheHill*. http://thehill.com/policy/energy-environment/250569-shell-to-leave-alec-over-climate-change-stance (September 25, 2017).

Huang, Ming-Yuan, Janaki R.R. Alavalapati, Douglas R. Carter, and Matthew H. Langholtz. 2007. "Is the Choice of Renewable Portfolio Standards Random?" *Energy Policy* 35(11): 5571–75.

Jacobs, Alan M. et al. 2019. *Transparency in Qualitative Research: An Overview of Key Findings and Recommendations (Introduction to Working Paper Series: Qualitative Transparency Deliberations, Working Group Final Reports)*. Rochester, NY: Social Science Research Network. SSRN Scholarly Paper. https://papers.ssrn.com/abstract=3430025 (May 15, 2020).

Jones, Charles A., and David L. Levy. 2007. "North American Business Strategies Towards Climate Change." *European Management Journal* 25(6): 428–40.

Jusko, Karen Long. 2014. "Electoral Geography, Strategic Mobilization, and Implications for Voter Turnout." *Working paper*.

———. 2015. "Electoral Geography and Redistributive Politics." *Journal of Theoretical Politics* 27(2): 269–87.

Karch, Andrew. 2007. "Emerging Issues and Future Directions in State Policy Diffusion Research." *State Politics & Policy Quarterly* 7(1): 54–80.

Layman, Geoffrey C., Thomas M. Carsey, and Juliana Menasce Horowitz. 2006. "Party Polarization in American Politics: Characteristics, Causes, and Consequences." *Annual Review of Political Science* 9(1): 83–110.

Lieberman, Evan S. 2005. "Nested Analysis as a Mixed-Method Strategy for Comparative Research." *American Political Science Review* 99(3): 435–52.

Lyon, Thomas P., and Haitao Yin. 2010. "Why Do States Adopt Renewable Portfolio Standards?: An Empirical Investigation." *The Energy Journal*: 133–157.

Matisoff, Daniel C. 2008. "The Adoption of State Climate Change Policies and Renewable Portfolio Standards: Regional Diffusion or Internal Determinants?" *Review of Policy Research* 25(6): 527–546.

McGinnis, Michael, and Elinor Ostrom. 2014. "Social-Ecological System Framework: Initial Changes and Continuing Challenges." *Ecology and Society* 19(2). https://www.ecologyandsociety.org/vol19/iss2/art30/ (June 11, 2020).

New State Ice Co. v. Liebmann. 1932. 285 US (Supreme Court).

North Carolina Clean Energy Technology Center. 2020. "Database of State Incentives for Renewables & Efficiency (DSIRE)." *DSIRE*. https://www.dsireusa.org/ (April 4, 2020).

Ostrom, Elinor. 2011. "Background on the Institutional Analysis and Development Framework." *Policy Studies Journal* 39(1): 7–27.

Ostrom, Elinor, Michael Cox, and Edella Schlager. 2014. "An Assessment of the Institutional Analysis and Development Framework and Introduction of the Social-Ecological Systems Framework." In *Theories of the Policy Process*, eds. Paul A. Sabatier and Christopher M. Weible. Boulder: Westview Press, 267–306.

Peabody, Robert L. et al. 1990. "Interviewing Political Elites." *PS: Political Science and Politics* 23(3): 451–55.

Rabe, Barry G. 2008. "States on Steroids: The Intergovernmental Odyssey of American Climate Policy." *Review of Policy Research* 25(2): 105–128.

"RGGI, Inc. | Program Overview." https://www.rggi.org/program-overview-and-design/elements (June 12, 2020).

Ringquist, Evan J., and James C. Garand. 1999. "Policy Change in the American States." *American state and local politics: Directions for the 21st century*: 268–285.

Saldaña, Johnny. 2013. *The Coding Manual for Qualitative Researchers*. 2nd ed. SAGE.

Seawright, Jason, and John Gerring. 2008. "Case Selection Techniques in Case Study Research: A Menu of Qualitative and Quantitative Options." *Political Research Quarterly* 61(2): 294–308.

Stoutenborough, James W., and Matthew Beverlin. 2008. "Encouraging Pollution-Free Energy: The Diffusion of State Net Metering Policies." *Social Science Quarterly* 89(5): 1230–1251.

Teddlie, Charles, and Abbas Tashakkori. 2009. *Foundations of Mixed Methods Research: Integrating Quantitative and Qualitative Approaches in the Social and Behavioral Sciences*. SAGE.

Trapenberg Frick, Karen, David Weinzimmer, and Paul Waddell. 2015. "The Politics of Sustainable Development Opposition: State Legislative Efforts to Stop the United Nation's Agenda 21 in the United States." *Urban Studies* 52(2): 209–32.

Walker, Jack L. 1969. "The Diffusion of Innovations among the American States*." *American Political Science Review* 63(3): 880–99.

"WCI, Inc. | Greenhouse Gas Emissions Trading: A Cost-Effective Solution to Climate Change." *WCI, Inc.* https://wci-inc.org (June 12, 2020).

Westervelt, Amy. 2015. "BP Joins List of Companies Fleeing ALEC." *The Guardian*. http://www.theguardian.com/sustainable-business/2015/mar/23/alec-bp-british-petroleum-companies-conservative-lobbyist (September 25, 2017).

Wiener, Joshua G., and Tomas M. Koontz. 2010. "Shifting Winds: Explaining Variation in State Policies to Promote Small-Scale Wind Energy." *Policy Studies Journal* 38(4): 629–51.

Wiser, Ryan, and Barbose, Galen. 2008. "Renewable Portfolio Standards in the United States-a Status Report with Data through 2007." *Lawrence Berkeley National Laboratory*. http://escholarship.org/uc/item/1r6047xb.pdf (February 13, 2017).

Wiser, Ryan, Kevin Porter, and Robert Grace. 2005. "Evaluating Experience with Renewables Portfolio Standards in the United States." *Mitigation and Adaptation Strategies for Global Change* 10(2): 237–63.

Yi, Hongtao. 2010. "The Politics of Renewable Portfolio Standards and Clean Energy Production in the States." https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1643785 (February 13, 2017).

Yin, Haitao, and Nicholas Powers. 2010. "Do State Renewable Portfolio Standards Promote In-State Renewable Generation?." *Energy Policy* 38(2): 1140–49.

References for Chapter Three

Adriázola, Paola et al. 2015. Report on EuTRACE Events: Policymakers' and Public Perspectives on Climate Engineering.

Allen, I. Elaine, and Christopher A. Seaman. 2007. "Statistics Roundtable: Likert Scales and Data Analyses." Quality Progress. http://asq.org/quality-progress/2007/07/statistics/likert-scales-and-data-analyses.html (February 11, 2017).

Anshelm, Jonas, and Anders Hansson. 2014. "The Last Chance to Save the Planet? An Analysis of the Geoengineering Advocacy Discourse in the Public Debate." Environmental Humanities 5(1): 101–123.

Awang, Zainudin. 2012. "A Handbook on SEM: Structural Equation Modelling." Shah Alam, Selangor Darul Ehsan: UiTM.

Carley, Sanya R. et al. 2012. "Early Public Impressions of Terrestrial Carbon Capture and Storage in a Coal-Intensive State." Environmental Science & Technology 46(13): 7086–93.

Carrico, Amanda R., Michael P. Vandenbergh, Paul C. Stern, and Gerald T. Gardner. 2011. "Energy and Climate Change: Key Lessons for Implementing the Behavioral Wedge." Geo. Wash. J. Energy & Envtl. L. 2: 61.

Corner, Adam, Nick Pidgeon, and Karen Parkhill. 2012. "Perceptions of Geoengineering: Public Attitudes, Stakeholder Perspectives, and the Challenge of 'Upstream' Engagement." Wiley Interdisciplinary Reviews: Climate Change 3(5): 451–66.

Cramton, Peter, David JC MacKay, Axel Ockenfels, and Steven Stoft. 2017. Global Carbon Pricing: The Path to Climate Cooperation. The MIT Press. https://www.oapen.org/search?identifier=1004043 (October 22, 2019).

Cusack, Daniela F. et al. 2014. "An Interdisciplinary Assessment of Climate Engineering Strategies." Frontiers in Ecology and the Environment 12(5): 280–87.

Dowd, Anne-Maree et al. 2014. "Investigating the Link between Knowledge and Perception of CO_2 and CCS: An International Study." International Journal of Greenhouse Gas Control 28: 79–87.

Fullerton, Don. 2001. "A Framework to Compare Environmental Policies." Southern Economic Journal 68(2): 224.

Gaskin, Cadeyrn J., and Brenda Happell. 2014. "On Exploratory Factor Analysis: A Review of Recent Evidence, an Assessment of Current Practice, and Recommendations for Future Use." International Journal of Nursing Studies 51(3): 511–21.

Gilens, Martin, and Benjamin I. Page. 2014. "Testing Theories of American Politics: Elites, Interest Groups, and Average Citizens." Perspectives on Politics 12(03): 564–81.

Hartley, James. 2014. “Some Thoughts on Likert-Type Scales.” International Journal of Clinical and Health Psychology 14(1): 83–86.

Hoshino, Takahiro, and Peter Bentler. 2011. “Bias in Factor Score Regression and a Simple Solution.” In Analysis of Mixed Data, eds. Alexander de Leon and Keumhee Chough. Chapman and Hall/CRC, 43–61. http://www.crcnetbase.com/doi/10.1201/b14571-5 (November 9, 2019).

“IAGP_Briefing_Note_1.Pdf.” http://iagp.ac.uk/sites/default/files/IAGP_Briefing_Note_1.pdf (September 4, 2019).

“IAGP_Briefing_Note_2.Pdf.” http://iagp.ac.uk/sites/default/files/IAGP_Briefing_Note_2.pdf (September 4, 2019).

“IAGP_Briefing_Note_3.Pdf.” http://iagp.ac.uk/sites/default/files/IAGP_Briefing_Note_3.pdf (September 4, 2019).

“IAGP_Briefing_Note_4.Pdf.” http://iagp.ac.uk/sites/default/files/IAGP_Briefing_Note_4.pdf (September 4, 2019).

Jamieson, Susan. 2004. “Likert Scales: How to (Ab)Use Them.” Medical Education 38(12): 1217–18.

Jenkins, Jesse D. 2019. Why Carbon Pricing Falls Short — And What To Do About It. Kleinman Center for Energy Policy. https://kleinmanenergy.upenn.edu/policy-digests/why-carbon-pricing-falls-short.

Jeremy B. White, and Andy Blatchford. 2019. “How California and Quebec Are Trying to Trump-Proof Their Climate Effort.” POLITICO. https://www.politico.com/news/2019/12/11/california-quebec-climate-change-082237 (December 16, 2019).

Jiahan, Cao. 2018. “Recalibrating China-U.S. Climate Cooperation Under the Trump Administration.” China Quarterly of International Strategic Studies 04(01): 77–93.

Johns, R. 2010. “Survey Question Bank: Methods Fact Sheet 1, Likert Items and Scales.” University of Strathclyde.

Kahan, Dan M. et al. 2015. “Geoengineering and Climate Change Polarization: Testing a Two-Channel Model of Science Communication.” The ANNALS of the American Academy of Political and Social Science 658(1): 192–222.

Krutilla, Kerry. 2011. “Transaction Costs and Environmental Policy: An Assessment Framework and Literature Review.” International Review of Environmental and Resource Economics 4(3–4): 261–354.

Kuzon Jr., William M., Melanie G. Urbanchek, and Steven McCabe. 1996. “The Seven Deadly Sins of Statistical Analysis.” Annals of Plastic Surgery 37(3): 265–72.

Layman, Geoffrey C. et al. 2010. “Activists and Conflict Extension in American Party Politics.” American Political Science Review 104(02): 324–46.

Layman, Geoffrey C., Thomas M. Carsey, and Juliana Menasce Horowitz. 2006. "Party Polarization in American Politics: Characteristics, Causes, and Consequences." Annual Review of Political Science 9(1): 83–110.

Liang, Pei. 2017. Unlocking the Deadlock: Promoting Low-Carbon Technology Cooperation between the United States and China after the Paris Agreement. Belfer Center for Science and International Affairs. https://www.belfercenter.org/publication/unlocking-deadlock (December 16, 2019).

L′Orange Seigo, Selma, Simone Dohle, and Michael Siegrist. 2014. "Public Perception of Carbon Capture and Storage (CCS): A Review." Renewable and Sustainable Energy Reviews 38: 848–63.

Mahajan, Aseem, Dustin Tingley, and Gernot Wagner. 2018. "Fast, Cheap, and Imperfect? US Public Opinion about Solar Geoengineering." Environmental Politics 28(3): 523–43.

Mercer, A. M., D. W. Keith, and J. D. Sharp. 2011. "Public Understanding of Solar Radiation Management." Environmental Research Letters 6(4): 044006.

Nashimoto, Kane, and F. T. Wright. 2007. "Nonparametric Multiple-Comparison Methods for Simply Ordered Medians." Comput. Stat. Data Anal. 51(10): 5068–5076.

Nauclér, Tomas, and Per-Anders Enkvist. 2009. Pathways to a Low-Carbon Economy: Version 2 of the Global Greenhouse Gas Abatement Cost Curve. McKinsey and Company.

Nordhaus, W. D. 2007. "To Tax or Not to Tax: Alternative Approaches to Slowing Global Warming." Review of Environmental Economics and Policy 1(1): 26–44.

Nordhaus, William. 2015. "Climate Clubs: Overcoming Free-Riding in International Climate Policy." American Economic Review 105(4): 1339–70.

Nordhaus, William D. 1992. "An Optimal Transition Path for Controlling Greenhouse Gases." Science 258(5086): 1315–19.

Norman, Geoff. 2010. "Likert Scales, Levels of Measurement and the 'Laws' of Statistics." Advances in Health Sciences Education 15(5): 625–32.

Pacala, Stephen, and Robert H. Socolow. 2004. "Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies." Science 305(5686): 968–72.

Pidgeon, N. et al. 2012. "Exploring Early Public Responses to Geoengineering." Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences 370(1974): 4176–96.

Rabe, Barry G. 2018. Can We Price Carbon? MIT Press.

Richards, Kenneth R. 2000. "Framing Environmental Policy Instrument Choice." Duke Envtl. L. & Pol'y F. 10: 221.

Schäfer, Stefan et al. 2015. The European Transdisciplinary Assessment of Climate Engineering (EuTRACE): Removing Greenhouse Gases from the Atmosphere and Reflecting Sunlight Away from Earth.

Scheer, Dirk, and Ortwin Renn. 2014. "Public Perception of Geoengineering and Its Consequences for Public Debate." Climatic Change 125(3–4): 305–18.

Sunstein, Cass R. 2007. "On the Divergent American Reactions to Terrorism and Climate Change." Columbia Law Review: 503–557.

SurveyMonkey. 2020. "Market Research Solutions Data Quality." SurveyMonkey. https://www.surveymonkey.com/market-research/data-quality/ (June 13, 2020).

Tavakol, Mohsen, and Reg Dennick. 2011. "Making Sense of Cronbach's Alpha." International Journal of Medical Education 2: 53–55.

Vaughan, Naomi. 2014. "IAGP Briefing Note 5: Public Views about Geoengineering."

Verchick, Robert RM. 2016. "Culture, Cognition, and Climate." U. Ill. L. Rev.: 969.

References for Chapter Four

Alberta, Government of. 2017. "New Funding That Puts CO_2 to Economic Use." https://www.alberta.ca/release.cfm?xID=46396DADC08A3-009F-810C-91C00204E6CFE432 (November 16, 2018).

Amador, Giana. 2016. *Philanthropy Beyond Carbon Neutrality*. Center for Carbon Removal. https://static1.squarespace.com/static/5b9362d89d5abb8c51d474f8/t/5c798e2ac830255b60c643bf/1551470125929/Philanthropy%2BReport%2BFinal%2B%28small%2Bfile%29.pdf (March 24, 2019).

Barrett, Scott et al. 2014. "Climate Engineering Reconsidered." *Nature Climate Change* 4: 527–29.

———. 2014. "Solar Geoengineering's Brave New World: Thoughts on the Governance of an Unprecedented Technology." *Review of Environmental Economics and Policy* 8(2): 249–69.

Baumgartner, Frank R. et al. 2009. *Lobbying and Policy Change: Who Wins, Who Loses, and Why*. University of Chicago Press.

Bodansky, Daniel. 2011. *Governing Climate Engineering: Scenarios for Analysis*. Rochester, NY: Social Science Research Network. SSRN Scholarly Paper. https://papers.ssrn.com/abstract=1963397 (April 2, 2019).

Bracmort, Kelsi, and Lattanzio, Richard K. 2013. *Geoengineering: Governance and Technology Policy*. Congressional Research Service.

"Carbon Engineering: History and Trajectory." *Carbon Engineering*. http://carbonengineering.com/history-and-trajectory/ (December 18, 2018).

Cardwell, Diane. 2014. "NRG Seeks to Cut 90% of Its Carbon Emissions." *The New York Times*. https://www.nytimes.com/2014/11/21/business/energy-environment/nrg-sets-goals-to-cut-carbon-emissions.html (December 18, 2018).

Corner, Adam, Nick Pidgeon, and Karen Parkhill. 2012. "Perceptions of Geoengineering: Public Attitudes, Stakeholder Perspectives, and the Challenge of 'Upstream' Engagement." *Wiley Interdisciplinary Reviews: Climate Change* 3(5): 451–66.

COSIA. "COSIA Is Mobilizing the World's Best Minds to Improve Environmental Performance | Canada's Oil Sands Innovation Alliance - COSIA." https://www.cosia.ca/about (December 18, 2018).

Cusack, Daniela F. et al. 2014. "An Interdisciplinary Assessment of Climate Engineering Strategies." *Frontiers in Ecology and the Environment* 12(5): 280–87.

Davis, Steven J, Long Cao, Ken Caldeira, and Martin I Hoffert. 2013. "Rethinking Wedges." *Environmental Research Letters* 8(1): 011001.

Dilling, Lisa, and Rachel Hauser. 2013. "Governing Geoengineering Research: Why, When and How?" *Climatic Change* 121(3): 553–65.

FICER. “Fund for Innovative Climate and Energy Research.” https://keith.seas.harvard.edu/FICER (November 8, 2018).

Frumhoff, Peter C., and Jennie C. Stephens. 2018. “Towards Legitimacy of the Solar Geoengineering Research Enterprise.” *Philosophical Transactions. Series A, Mathematical, Physical, and Engineering Sciences* 376(2119).

Fullerton, Don. 2001. “A Framework to Compare Environmental Policies.” *Southern Economic Journal* 68(2): 224.

Fuss, Sabine et al. 2018. “Negative Emissions—Part 2: Costs, Potentials and Side Effects.” *Environmental Research Letters* 13(6): 063002.

Gardiner, Stephen M. 2011. “Some Early Ethics of Geoengineering the Climate: A Commentary on the Values of the Royal Society Report.” *Environmental Values* 20(2): 163–88.

“Geoengineering Monitor.” *Geoengineering Monitor*. http://www.geoengineeringmonitor.org (March 17, 2019).

Gilens, Martin. 2012. *Affluence and Influence: Economic Inequality and Political Power in America*. Princeton University Press. Supplementary material: https://www.russellsage.org/economic-inequality-and-political-representation.

Gilens, Martin, and Benjamin I. Page. 2014. “Testing Theories of American Politics: Elites, Interest Groups, and Average Citizens.” *Perspectives on Politics* 12(03): 564–81.

Government Accountability Office. 2010a. *Climate Change: Preliminary Observations on Geoengineering Science, Federal Efforts, and Governance Issues*.

———. 2010b. *Climate Change: A Coordinated Strategy Could Focus Federal Geoengineering Research and Inform Governance Efforts*.

———. 2011. *Technology Assessment: Climate Engineering: Technical Status, Future Directions, and Potential Responses*. http://www.gao.gov/products/GAO-11-71 (January 19, 2017).

Grubb, Michael. 2004. “Technical Innovation and Climate Change Policy: An Overview of Issues and Options.” *Keio Economic Studies* 41(2): 103–32.

Hahn, Robert et al. 2011. *Thinking through the Climate Change Challenge*. Sustainable Consumption Institute, University of Manchester.

Heyward, Clare. 2013. “Situating and Abandoning Geoengineering: A Typology of Five Responses to Dangerous Climate Change.” *PS: Political Science & Politics* 46(01): 23–27.

Honegger, Matthias, and David Reiner. 2018. “The Political Economy of Negative Emissions Technologies: Consequences for International Policy Design.” *Climate Policy* 18(3): 306–21.

House of Representatives, U.S., and Bart Gordon. 2010. “Engineering the Climate: Research Needs and Strategies for International Coordination.” In *Committee on Science and Technology, US House of*

Representatives, One Hundred Eleventh Congress, Second Session, http://foodbitsandbites.com/pdf/US_House_Science_and_Tech_Report_on_Geoengineering.pdf (January 19, 2017).

Humphreys, David. 2011. "Smoke and Mirrors: Some Reflections on the Science and Politics of Geoengineering." *The Journal of Environment & Development* 20(2): 99–120.

IPCC. 2014. *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. eds. R. K. Pachauri and Leo Mayer. Geneva, Switzerland: Intergovernmental Panel on Climate Change.

John, Jeff St. 2009. "APS Gets $70.5M to Feed Captured Carbon to Algae." https://www.greentechmedia.com/articles/read/aps-gets-70-5m-to-feed-captured-carbon-to-algae (November 16, 2018).

Kahan, Dan M. et al. 2015. "Geoengineering and Climate Change Polarization: Testing a Two-Channel Model of Science Communication." *The ANNALS of the American Academy of Political and Social Science* 658(1): 192–222.

Keith, David W., Geoffrey Holmes, David St Angelo, and Kenton Heidel. 2018. "A Process for Capturing CO_2 from the Atmosphere." *Joule* 2(8): 1573–94.

"Keith Group, The." *The Keith Group*. https://keith.seas.harvard.edu/home (December 18, 2018).

Kolbert, Elizabeth. 2017. "Can Carbon-Dioxide Removal Save the World?" https://www.newyorker.com/magazine/2017/11/20/can-carbon-dioxide-removal-save-the-world (December 18, 2018).

Krieger, Lisa. 2015. "Cloud Brightening Experiment Tests Tool to Slow Climate Change." *The Mercury News*. https://www.mercurynews.com/2015/07/11/cloud-brightening-experiment-tests-tool-to-slow-climate-change/ (March 26, 2019).

Krutilla, Kerry. 2011. "Transaction Costs and Environmental Policy: An Assessment Framework and Literature Review." *International Review of Environmental and Resource Economics* 4(3–4): 261–354.

Laakso, A. et al. 2016. "Radiative and Climate Impacts of a Large Volcanic Eruption during Stratospheric Sulfur Geoengineering." *Atmospheric Chemistry and Physics* 16(1): 305–23.

Latham, John et al. 2012. "Marine Cloud Brightening." *Phil. Trans. R. Soc. A* 370(1974): 4217–62.

"Leverhulme Centre - Theme 3 – Applied Weathering Science." *Leverhulme Centre for Climate Change Mitigation (LC3M)*. http://lc3m.org/research/theme-3/ (December 18, 2018).

Long, Jane C. S., Frank Loy, and M. Granger Morgan. 2015. "Policy: Start Research on Climate Engineering." *Nature News* 518(7537): 29.

MacCracken, Michael C. 2016. "The Rationale for Accelerating Regionally Focused Climate Intervention Research." *Earth's Future* 4(12): 649–57.

McCullough, Michael. 2016. "How Carbon Engineering Plans to Make a Fortune out of Thin Air." *Canadian Business*. https://www.canadianbusiness.com/lists-and-rankings/most-innovative-companies/carbon-engineering/ (December 18, 2018).

Mercer, A. M., D. W. Keith, and J. D. Sharp. 2011. "Public Understanding of Solar Radiation Management." *Environmental Research Letters* 6(4): 044006.

Merk, Christine, Gert Pönitzsch, and Katrin Rehdanz. 2019. "Do Climate Engineering Experts Display Moral-Hazard Behaviour?" *Climate Policy* 19(2): 231–43.

Minx, Jan C. et al. 2018. "Negative Emissions—Part 1: Research Landscape and Synthesis." *Environmental Research Letters* 13(6): 063001.

National Research Council. 2015a. *Climate Intervention: Carbon Dioxide Removal and Reliable Sequestration*. Washington, D.C.: National Academies Press. http://www.nap.edu/catalog/18805 (January 19, 2017).

———. 2015b. *Climate Intervention: Reflecting Sunlight to Cool Earth*. https://www.nap.edu/catalog/18988/climate-intervention-reflecting-sunlight-to-cool-earth (April 2, 2019).

"NSF Award Search: Award#1157525 - Impacts of Geoengineering Using Stratospheric Aerosols." 2012. https://www.nsf.gov/awardsearch/showAward?AWD_ID=1157525&HistoricalAwards=false (November 2, 2018).

"NSF Award Search: Award#1240507 - What Are Sustainable Climate-Risk Management Strategies?" 2012. https://www.nsf.gov/awardsearch/showAward?AWD_ID=1240507 (November 2, 2018).

Pacala, Stephen, and Robert H. Socolow. 2004. "Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies." *Science* 305(5686): 968–72.

Parson, Edward A., and David W. Keith. 2013. "End the Deadlock on Governance of Geoengineering Research." *Science* 339: 1278–79.

Peters, Adele. 2017. "Can We Suck Enough CO_2 From The Air To Save The Climate?" *Fast Company*. https://www.fastcompany.com/40510680/can-we-suck-enough-co2-from-the-air-to-save-the-climate (March 26, 2019).

Pidgeon, N. et al. 2012. "Exploring Early Public Responses to Geoengineering." *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 370(1974): 4176–96.

PrivCo. "Cool Planet Energy Systems - Financial Report | Annual Revenue | Stock." *PrivCo*. https://www-privco-com.proxyiub.uits.iu.edu/private-company/coolplanet-energy-systems-llc (December 18, 2018).

Ragin, Charles C. 1987. *The Comparative Method: Moving Beyond Qualitative and Quantitative Strategies*. University of California Press.

———. 2008. *Redesigning Social Inquiry: Fuzzy Sets and Beyond*. University of Chicago Press.

Rayner, Steve et al. 2009. "Memorandum on Draft Principles for the Conduct of Geoengineering Research." http://www.geoengineering.ox.ac.uk/oxford-principles/history/ (April 2, 2019).

———. 2013. "The Oxford Principles." *Climatic Change* 121(3): 499–512.

———. 2014. *To Know or Not to Know? A Note on Ignorance as a Rhetorical Resource in Geoengineering Debates*. Geoengineering Governance Research Working Paper 10. http://geoengineering-governance-research.org/perch/resources/workingpaper10raynertoknowornottoknow-1.pdf (January 19, 2017).

Richards, Kenneth R. 2000. "Framing Environmental Policy Instrument Choice." *Duke Envtl. L. & Pol'y F.* 10: 221.

Royal Society (Great Britain). 2009. *Geoengineering the Climate: Science, Governance and Uncertainty*. London: Royal Society. http://royalsociety.org/uploadedFiles/Royal_Society_Content/policy/publications/2009/8693.pdf (January 19, 2017).

Ruz, Camila. 2011. "Scientists Criticise Handling of Pilot Project to 'geoengineer' Climate." *The Guardian*. https://www.theguardian.com/environment/2011/nov/17/scientists-criticise-project-geoengineer-climate (March 26, 2019).

Schäfer, Stefan et al. 2015. *The European Transdisciplinary Assessment of Climate Engineering (EuTRACE): Removing Greenhouse Gases from the Atmosphere and Reflecting Sunlight Away from Earth*.

Schneider, Carsten Q., and Claudius Wagemann. 2010. "Standards of Good Practice in Qualitative Comparative Analysis (QCA) and Fuzzy-Sets." *Comparative Sociology* 9(3): 397–418.

———. 2012. *Set-Theoretic Methods for the Social Sciences: A Guide to Qualitative Comparative Analysis*. Cambridge University Press.

Schneider, S. H. 2008. "Geoengineering: Could We or Should We Make It Work?" *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 366(1882): 3843–62.

"SCoPEx." https://projects.iq.harvard.edu/keutschgroup/scopex (December 18, 2018).

"SCRiM Overview." http://www.scrimhub.org/about/overview/ (November 15, 2018).

"SCRiM Projects." http://www.scrimhub.org/research/projects/ (November 2, 2018).

Service, Robert F. 2018. "Cost Plunges for Capturing Carbon Dioxide from the Air." *Science | AAAS*. https://www.sciencemag.org/news/2018/06/cost-plunges-capturing-carbon-dioxide-air (November 27, 2018).

Socolow, Robert H., and Alexander Glaser. 2009. "Balancing Risks: Nuclear Energy & Climate Change." *Daedalus* 138(4): 31–44.

SurveyMonkey. 2020. "Market Research Solutions Data Quality." *SurveyMonkey*. https://www.surveymonkey.com/market-research/data-quality/ (June 13, 2020).

Tollefson, Jeff. 2010. "Geoengineering Faces Ban." *Nature* 468(7320): 13–14.

U.S. Global Change Research Program. 2017. *National Global Change Research Plan 2012-2021: A Triennial Update*. Washington, D.C.

Vaughan, Naomi E., and Timothy M. Lenton. 2011. "A Review of Climate Geoengineering Proposals." *Climatic Change* 109(3–4): 745–90.

Vidal, John. 2018. "How Bill Gates Aims to Clean up the Planet." *The Observer*. https://www.theguardian.com/environment/2018/feb/04/carbon-emissions-negative-emissions-technologies-capture-storage-bill-gates (December 18, 2018).

Vinluan, Frank. 2017. "Xconomy: Rebooted and Refocused, Startup Cool Planet Eyes the Soil Market." *Xconomy*. https://xconomy.com/boulder-denver/2017/03/24/rebooted-and-refocused-startup-cool-planet-eyes-the-soil-market/ (December 18, 2018).

Welch, Aaron, Sarah Gaines, Tony Marjoram, and Luciano Fonseca. 2012. "Climate Engineering: The Way Forward?" *Environmental Development* 2: 57–72.

Wesoff, Eric. 2017. "Hard Lessons From the Great Algae Biofuel Bubble." https://www.greentechmedia.com/articles/read/lessons-from-the-great-algae-biofuel-bubble (November 16, 2018).

XPrize Foundation. "Carbon XPRIZE." *XPRIZE*. https://carbon.xprize.org/prizes/carbon (December 18, 2018).

CHRISTOPHER J. MILLER

Indiana University
O'Neill School of Public & Environmental Affairs (SPEA)
1315 East 10th Street, Rm 441
Bloomington, Indiana 47405
cjm3@indiana.edu

EDUCATION

Indiana University O'Neill School of Public & Environmental Affairs, Bloomington, Indiana — Joint Ph.D. in Public Policy (August 2020)

- Comprehensive Exam Fields: Environmental Policy, Public Policy, American Politics
- Dissertation: *Climate Policy and Political Viability: Polarization, Inequality, and the Prospects for Geoengineering*
- Committee: Daniel Cole (chair), Lisa Blomgren Amsler, Marjorie Hershey, Sean Nicholson-Crotty

Case Western Reserve University School of Law, Cleveland, Ohio — J.D.

- Thesis: *Protection versus Emancipation: Children's Rights in Historical Perspective*

The University of Chicago, Chicago, Illinois — A.B., Political Science

- Thesis: *Turning Point: Kent State and Perceptions of Political Protest*

PUBLICATIONS

Carley, Sanya, Sean Nicholson-Crotty, and **Chris J. Miller**. 2017. "Adoption, Reinvention, and Amendment of Renewable Portfolio Standards in the American States." *Journal of Public Policy* 37(4): 431-458.

Carley, Sanya, and **Chris J. Miller**. 2012. "Regulatory Stringency and Policy Drivers: A Reassessment of Renewable Portfolio Standards." *Policy Studies Journal* 40(4): 730-756.

UNDER REVIEW

Miller, Chris J. "Catching Carbon with NETs: Case Studies in Elite Institutional Support and the Political Viability of Geoengineering."

WORKS IN PROGRESS

Miller, Chris J. "Climate Policy and Political Viability: Representational Inequality and Economic Elite Attitudes."

CONFERENCES AND RESEARCH PRESENTATIONS

"Climate Policy and Political Viability: Case Studies in Elite Institutional Support." Paper presented at Western Political Science Association annual conference, 2019: panel on Climate and Public Opinion

"Climate Policy and Political Viability: Case Studies in Elite Institutional Support." Paper presented at Midwest Political Science Association annual conference, 2019: panel on Domestic and Global Factors in Climate Policy

“Climate Policy and Political Viability: Prospects in an Age of Biased Pluralism.” Paper presented at Southern Political Science Association annual conference, 2017: panel on The Politics of Policy Elites

“Digital Home Style: Variable Models of Candidate Self-Presentation.” Paper presented at Midwest Political Science Association annual conference, 2015: panel on Press Management in the Digital Age.

“Inequality and Climate Change: Exploring Consequences of Economic Disparities.” Paper presented at Midwest Political Science Association annual conference, 2013: panel on International Climate Policy.

“Adoption and Diffusion of State Energy Policies: A Comparative Assessment.” Paper presented at Association for Public Policy Analysis & Management annual conference, 2012: panel on Environmental and Energy Policy in the States.

“Regulatory Stringency and Policy Drivers: A Reassessment of Renewable Portfolio Standards.” Paper presented at Midwest Political Science Association annual conference, 2012: panel on Environmental Policy in the American States.

TEACHING

As instructor of record:
Y319: U.S. Congress — Instructor
Department of Political Science, Indiana University, Spring 2020.

P101: Introduction to American Government — Adjunct Instructor
Department of Political Science, Ivy Tech Community College, Fall 2017.

Y313: Environmental Policy — Co-Instructor (with Adam Abelkop)
Department of Political Science, Indiana University, Fall 2015.

Y303: Policymaking in the U.S.: Problems, Processes, and Theories — Instructor
Department of Political Science, Indiana University, Summer 2015.

V220: Law and Public Affairs — Instructor
School of Public and Environmental Affairs, Indiana University, Spring 2015, Fall 2015, Spring 2016.

K300: Statistical Techniques — Instructor
School of Public and Environmental Affairs, Indiana University, Spring 2014.

V160: National and International Policy — Instructor
School of Public and Environmental Affairs, Indiana University, Spring 2013, Fall 2013, Fall 2014, Summer 2015.

As course assistant:
Y100: American Political Controversies — Associate Instructor (for Jacek Dalecki)
Department of Political Science, Indiana University, Fall 2019.

A383: Rock, Hip-Hop, and Revolution — Associate Instructor (for Michael McGerr)
Department of History, Indiana University, Spring 2019.

A382: The Sixties in America — Associate Instructor (for Michael McGerr)
Department of History, Indiana University, Fall 2018.

Y103: Introduction to American Politics — Associate Instructor (for William Bianco)
Department of Political Science, Indiana University, Spring 2017.

RESEARCH EXPERIENCE

Indiana University, Bloomington, Indiana
Graduate Assistant to Dr. Barry Rubin (summers, 2014-2015) and Dr. Trent Engbers (summer 2018)
V550: Topics in Public Affairs (SPEA Connect course)
Supported Dr. Rubin (founding director of the program) and later Dr. Engbers in coordinating the SPEA Connect summer program for online Masters students. Researched issues and strategies, interfaced with real-world clients, prepared curricular materials, and coached students through analysis, preparation, and presentation of their final deliverables.

Graduate Research Assistant to Center for International Business Education and Research (CIBER) (summer 2013)
Researched and wrote program development report to assist students in navigating the challenges and leveraging the benefits of overseas study.

Graduate Research Assistant to Dr. Sanya Carley (2010-2012)
Researched and reviewed existing literature, compiled and analyzed data, and co-authored and edited articles and grants related to ongoing projects on state-level renewable energy policy alternatives.

GRANT WRITING EXPERIENCE

Grant writers: Carley, Sanya, and Chris J. Miller. **NSF Science, Technology, and Society** proposal: "Policy Diffusion and State Renewable Energy Policies: A New Theoretical Framework." $50,000. Not funded.

ADDITIONAL TRAINING AND RESEARCH

Survey Designer on student housing preferences for the Bloomington, Indiana, Office of Economic and Sustainable Development, 2014.

Study-abroad program in International Environmental Governance and Climate Policy: Oxford University (Wolfson College), Oxford, England, 2011.

OTHER PROFESSIONAL EXPERIENCE

Equality Illinois, Chicago, Illinois
Executive Director (2006-2008)
Served as chief operating officer, with overall responsibility for fundraising, public relations, and fiscal management and administration. Worked in concert with Director of Public Policy to facilitate civil liberties advocacy initiatives and public information programs.

League of Women Voters of Chicago, Chicago, Illinois
Associate Director (2003-2005)

Promoted and strengthened electoral oversight programs and other League projects and policies via a wide range of strategic communications to local media, the public, and League allies. Represented the League to student, professional, and community groups through public forums and speaking appearances. Also managed organizational finances, budgeting, and reporting.

Chris Miller & Associates, Chicago, Illinois
Independent Practice (1993-2003, 2008-2010)

Provided broad range of legal, management, and technical consulting services to small business and nonprofit clients.

RESEARCH INTERESTS

American politics, public policy formation, climate change, environmental law, regulatory compliance, polarization, inequality, public opinion, survey research, mixed-methods research, civil liberties.

AWARDS AND HONORS

Indiana University

- John Gillespie Fellowship — Conference Travel Award, 2019
- F & E Payne Fellowship — Conference Travel Award, 2019
- Indiana University Graduate School — Grant in Aid of Doctoral Research, 2018
- Center on American Politics — Conference Travel Award, 2015
- IU Office of Sustainability — Graduate Research Development Grant, 2013

Case Western Reserve University

- Dunmore Moot Court competition finalist (second year) and advisor (third year)
- Selected for Dean's Tutorial Program to tutor first-year law students in legal writing
- Law School Academic Scholarship recipient

University of Chicago

- Summer study-abroad program in the Liberal Arts: Oxford University (New College), Oxford, England
- Appel Scholarship recipient for academic achievement
- National Merit Scholarship recipient

PROFESSIONAL SERVICE

Student instructor participant, SPEA committee on undergraduate curriculum, 2015
Peer reviewer, *Policy Studies Journal*, 2013
Discussant at Association for Public Policy Analysis & Management annual conference, 2012: panel on Carbon Capture and Sequestration Policy
Political Science Graduate Student Association, American Politics field representative, 2011-2013
Association of SPEA Ph.D. Students, Outreach Chair, 2011-2012

PROFESSIONAL MEMBERSHIPS

American Political Science Association
Midwest Political Science Association
State Bar of Illinois (inactive)